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SOME PROBLEMS IN INFECTION AND ITS CONTROL[1]

I EXPERIENCE a high sense of honor on this occasion with which is mingled no less trepidation in view of the master in whose memory this lectureship was founded, and the great names that in the past have been linked with the post I am to-day asked to fill. I must believe that Huxley would have felt a deep interest in the theme which I have chosen to discuss before you and would have found in its intrinsic importance a compensation for any shortcoming that may appear in the presentation. For Huxley evinced a penetrating appreciation of that branch of biological science that has come to be called bacteriology, and as president of the British Association in 1870 devoted the occasion of his address to an illuminating examination of the doctrine of abiogenesis, or spontaneous generation, versus the doctrine of biogenesis or descent from living ancestors. This subject, long holding a merely academic interest, had become in the two decades immediately preceding the ground over which the conflict raged and out of which was to emerge the modern science of microbiology. While Huxley clearly pointed out that Redi in the seventeenth century and Spallanzani in the eighteenth had delivered the first telling blows that later, through Pasteur, led to the overwhelming defeat of the spontaneous generationists and the establishment on an indisputable basis of the extrinsic origin of the contagious and infectious diseases, he did not fail

[1] The Huxley lecture, delivered at Charing Cross Hospital School of Medicine, London, October 31, 1912.

to preserve in the discoveries just being made in reference to fermentation, putrefaction, and certain fungus and other diseases of insects, the herald of the new science that was to throw its protecting mantle not about man alone, but about all the higher animals and even about the plants, in order that the useful and indispensable should be protected from that inevitable contest in nature between higher and lower forms of life which constitutes disease and leads to premature decay and ruthless destruction.

Bacteriology has, up to now, distributed its favors unequally, but we must not be daunted by this circumstance. It has yielded, in some instances, knowledge of diseases of small, and withheld, in others, knowledge of diseases of great importance. In respect to the common and highly contagious diseases, measles and scarlet fever, for example, progress has been slight. A ray of hope has been cast upon this quest by the announcement[2] that measles can be caused in the monkey by inoculation of infected blood, but this awaits certain confirmation. Similar announcements have been made recently regarding scarlet fever.[3] Since a flood of knowledge has always suddenly flowed from the successful transmission of an obscure disease to the lower animals these reports have been viewed with eager expectation. In the case of scarlet fever I fear the expectation is not yet to be realized. We[4] spent last winter in the study of this subject and failed completely to infect or produce scarlet fever in a wide variety of lower monkeys. Possibly, but not certainly, the higher anthropoid ape, which is still less removed from the human species, is subject to inoculation.[5] The path of success in relation to the refractory diseases is marked by heavy obstacles, but it must be travelled none the less. How often indeed has crowning success come to the brave, thoughtful and adventurous when all but an expiring glimmer of hope had gone! Witness in this connection the sudden conquest of syphilis, in which the initial victory was won when it was ascertained that anthropoid apes can be infected experimentally. There followed in rapid succession the discovery of the causative spirocheta, the Wassermann clinical test and the fabulous drug, salvarsan, the usefulness of which outruns the wide bounds of syphilis itself.

But even after such a victory the drama had not come to an end. The spirochetal cause could now be discovered regularly where it had been as constantly missed before; doubts and disbeliefs in it were quickly yielding before the rapidly accumulating evidence; but the microorganism itself resisted all attempts at artificial cultivation. That the spirocheta is a parasite nicely adjusted to living tissues was clear from the difficulties surrounding the experimental inoculation of animals. Now this act also has been played.[6] The pallida has yielded to artificial culture by Noguchi and the method sufficing for it has suddenly exposed the whole class of disease-producing spirochetæ and some innocent species as well, to cultivation and ex-

[2] Anderson and Goldberger, *Bulletin of the U. S. Public Health and Marine Hospital Service*, 1911, No. 62.

[3] Cantacuzène, *Comptes rendus de la Société de biologie*, 1911, LXX., 403. Bernhardt, *Deutsche medizinische Wochenschrift*, 1911, XXXVII., 791, 1062; *Centralblatt für Bakteriologie, Parasitenkunde und Infectionskrankheiten*, Abteilung 1, Referate, Supplement, 1911, I., 27.

[4] Draper, George, unpublished studies.

[5] Landsteiner, Levaditi, and Prasek, *Annales de l'Institut Pasteur*, 1911, XXV., 754.

[6] Noguchi, *Journal of Experimental Medicine*, 1911, XIV., 99; 1912, XV., 90; 1911, XIV., 557; 1912, XVI., 199.

ploitation under laboratory conditions. It is obvious that the more nicely a parasitic organism is adjusted to its host the more difficult it will be to cultivate it outside the host and the more quickly it will lose in culture its pathogenic power. The pallidum, which for so long resisted the efforts to transmit it artificially to animals and then to cultivate it outside *in vitro*, loses after a few generations, as was to be expected, its disease-producing virulence, while the blood parasites of relapsing and tick fevers in man and spirillosis in fowls, which are strictly parasitic and pass a stage of their life in biting insects, retain this power for many generations. In turn, the culture of the pallida has yielded luetin which by causing a local allergic or hypersensitive skin reaction has provided clinical medicine with a new means of detecting latent luetic infection.

With this introduction to the more general theme of the hour I shall invite you to follow with me somewhat minutely the biological investigations of a disease that is still claiming the absorbed attention of both physicians and people, namely, poliomyelitis, or infantile paralysis. The disease has just been making the rounds of the world, coming as a very unwelcome intruder to many different countries. Until the present pandemic it was surrounded with mystery and fortified by superstition. It is the story of the working out of the natural history of poliomyelitis, now elucidated in many ways, that I propose to tell you. I have been led to choose this particular disease as my theme, both because it has claimed much of my attention during the past several years, and because it illustrates admirably certain general truths to which I desire to call your attention.

Poliomyelitis has been endemic in northern Europe for many years, but it is only five years since it started on that unique, and as yet unexplained, movement that has carried it around the globe. In America there is no previous history of a general prevalence or epidemic, although local outbreaks of infantile paralysis have from time to time arisen. Some significance attaches to the fact that the first two foci of the present epidemic—I say present, because since 1907 the disease has prevailed severely each summer and autumn at some places in the United States and Canada—arose in the Atlantic coast cities and in the state of Minnesota in the middle west. The former receive the mass of emigrant population from Europe, and the latter, secondarily, the large contingent of Scandinavian emigrants. The imposition of the infection upon America can thus be accounted for; but no explanation is afforded of the many years of immunity while Scandinavians were constantly arriving, and for the penetration of the disease to other European countries and to far distant parts of the world. However, within the pandemic period the disease has taken on new activity in Norway and Sweden, and as recently as 1911 the latter country has suffered a severe visitation.

On clinical grounds Scandinavian observers[7] had recognized the essentially infectious nature of poliomyelitis and had followed the evolution of the outbreaks and traced the connection between many of the cases. They became the defenders of the notion of human carriage, and by establishing certain unusual clinical forms of the disease—such as meningeal and abortive—placed this idea on firm ground. The notion was further extended to include healthy carriers of the infection who act as intermediaries between the actively ill and the new victims of infection. These

[7] Wickman, "Beiträge zur Kenntnis der Heine-Medinschen Krankheit," Berlin, 1907.

views have all alike been treated with more or less scepticism by the medical profession; in how far they have come to be supported by later acquisitions of knowledge will appear.

Apart then from these deductions, disputed and disputable, because not supported by certain tests, five years ago the mystery of the disease was wholly unfathomed. The outlook was suddenly brightened when Landsteiner and Popper in 1909[8] announced the successful transmission of poliomyelitis to monkeys, but the high hopes raised were as quickly dampened by the failure to propagate the experimental disease beyond the first generation. This obstacle was immediately removed when intracerebral was substituted for intraperitoneal inoculation, as was done by Lewis and myself[9] and by Landsteiner and Levaditi.[10] By this means the disease could be and has been transmitted through an indefinite number of monkeys. The inoculating matter is, first, the sterile spinal cord of a fatal human case, and, afterwards, the spinal cord of paralyzed monkeys.

The choice of the intracerebral route as superior to the intraperitoneal was not haphazard. All the severe effects of poliomyelitis are inflicted on the nervous system, and upon reflection this fact at once suggested that the parasitic cause of the disease must find favorable conditions for multiplication within the nervous tissues. When the material carrying the germ is put first into the peritoneal cavity it must traverse the blood before it can reach the nervous system, and the blood, as we know, has the power to destroy many forms of germ life. It could, of course, also be reasoned that the specific parasite, in nature, can not enter the nervous tissues directly but must use some external route to reach them, and it must, therefore, be capable of surviving outside the brain and spinal cord; and it could be further reasoned that an inoculation into a more accessible part of the body than the brain and spinal cord should be effective, and if effective would bring stronger proof of the actual existence of a parasite in the inoculated matter. This reasoning is unconvincing for two causes: first, the monkey is not naturally subject to poliomyelitis and is, therefore, presumably more difficult to infect at all than is man so that what may suffice to cause infection in man may fail in the monkey; and, second, it might be possible for pathogenic microbes to reach the central nervous system even in man without entering the blood at all so that in nature the infectious cause of poliomyelitis might avoid the blood altogether. That this possibility really exists has been proved by experiment, as we shall see. Doubtless the first material inoculated into the abdominal cavity carried besides the living parasites toxic or other injurious substances that promoted infection in the monkey; but when the nervous tissues of the monkey were similarly injected, being less harmful, the inoculation failed. Bacteriology contains many instances of similar, and apparently of paradoxical nature.

The discrepancy has been further elucidated, as will soon appear, but in the meantime it is desirable to inquire whether

[8] Landsteiner and Popper, *Zeitschrift für Immunitätsforschung, Originale,* 1909, II., 377.

[9] Flexner and Lewis, *Journal of the American Medical Association,* 1909, LIII., 1639; *Journal of Experimental Medicine,* 1910, XII., 227. Flexner, *Journal of the American Medical Association,* 1910, LV., 1105. Flexner and Clark, *Journal of the American Medical Association,* 1911, LVII., 1685. Howard and Clark, *Journal of Experimental Medicine,* 1912, XVI., 850.

[10] For a general bibliography, see Römer, "Die epidemische Kinderlähmung" (Heine-Medinsche Krankheit), Berlin, 1911.

still other routes of infection exist for the monkey. Since nervous tissue is favorable to the parasite it was injected into large nerves—such as the sciatic—in order to ascertain whether these furnished a suitable medium of propagation. The parasite grows along the nerve until the spinal cord is reached and produces injury of the cord first at the point of entrance before it extends to and attacks other parts. The injection into the nerve causes no paralysis but paralysis of the innervated muscles appears after the lapse of a time sufficient for the necessary multiplication of the parasite and its passage into the spinal cord.

Meanwhile the inoculated monkey shows no other signs of illness, and no other organ is severely affected; the injury is centered upon the nervous tissues. And not only does the parasite grow or flow along the nerve but it ascends along the spinal cord from lower to higher levels and eventually reaches the medulla and brain. At last the centers governing respiration are involved and death by paralysis ensues.

We have now been able to arrive at several important conclusions. The monkey can be made regularly to develop an experimental disease agreeing in all essential respects with poliomyelitis in man. Inoculation is necessary since keeping healthy and paralyzed monkeys together does not lead to infection. The parasitic cause of the disease can traverse the blood, in the monkey, to reach the central nervous organs, but with difficulty, while it easily traverses the peripheral nerves. That the natural, spontaneous disease, so called, in man and the induced disease in monkeys are very much alike is further shown by microscopic study of the spinal cord and brain which exhibit changes that are identical.

The pathological effects are of two kinds: injury to nerve cells not in the anterior gray matter alone but in the posterior gray matter of the spinal cord and in the intervertebral ganglia, medulla and brain; and cellular invasion of the pia-arachnoidal membrane of the spinal cord and medulla that follow the blood vessels into these parts and pass into the adjacent gray and white matter. The altered vessels permit an escape of albuminous fluid and blood cells into the meshes of the membrane where they mingle with the cerebrospinal liquid, and into the spaces in the tissue composing the solid white and gray matter. Sometimes the nerve cells, sometimes the meninges, vessels and supporting tissues suffer most. When the nerve cells are extensively injured the paralysis is marked; when the meninges are much affected, the symptoms are like those of meningitis. The virus of poliomyelitis displays a high affinity for nervous tissues, but it is the wide involvement of the nutritive vascular system in the pathological process that subjects the sensitive nerve cells to so high a degree of injury and destruction.

The microscopical conditions we observed in the course of our experiments were suggestive of two things: first, the nature of the parasite itself, and, second, the process of generation of the effects or lesions themselves. Up to this time no definite parasite could be detected in the nervous tissues either in human beings or monkeys, nor was anything of the kind found in the blood or other organs. The scarcity of polynuclear leucocytes in the altered cerebrospinal liquid and spinal cord itself spoke against a simple bacterial parasite. The large number of mononuclear cells spoke rather for a protozoal parasite. Neither could be found, although the most varied methods of staining and cultivation were employed. There remained the possibility of the parasite being invisible or ultramicroscopic and filterable. This it

proved to be, for when a portion of the spinal cord of a recently paralyzed monkey was made into an emulsion with sterile distilled water, or simple saline solution, and then centrifugalized to remove the coarse suspended matter and afterwards pressed through a Berkefeld earthenware filter, which excludes ordinary cells, bacteria and protozoa, the clear liquid resulting was still capable of transmitting the disease. The activity of the filtrate is very great, since a fraction of a cubic centimeter still suffices to cause paralysis and death. The only distinction to be noted between the action of corresponding amounts of the emulsion and filtered fluid is that the former acts more quickly, as would be expected from the fact that it contains a greater number of the invisible organisms. This difference is soon compensated by the multiplication of those in the filtrate so that the end result is the same. By employing somewhat greater quantities of the filtrate for inoculation the incubation period of the disease can be made the same as that following the use of the emulsion. The disparity is strictly a quantitative one, since the filters retain a part of the minute organisms in their pores and thus reduce the number escaping with the filtrate. The greater the quantity of protein matter present in the fluid the fewer the parasites that pass the filter, and merely because the large protein molecules themselves tend to be held in the pores and thus render them impervious for the minute organisms. For this reason, also, fluids containing small numbers of the filterable parasites, but still sufficient to cause infection in the crude state, may fail, when filtered, to produce disease merely because those retained by the filter so far reduce the numbers as to bring them below the surely infecting dose. This reduction sometimes leads to another effect; namely, the slight degree of infection that forms the starting point of active immunization. By building upon such a beginning a high and enduring state of immunity has been achieved.

The first filterable parasite was discovered by Loeffler fourteen years ago, in the fluid lymph obtained from the vesicles of cattle suffering from foot and mouth disease. At the present time eighteen diseases are known that are believed on good ground to be caused by this class of minute living organisms. One alone among them is on the verge of visibility—the parasite causing pleuropneumonia of cattle. It alone has certainly been obtained in artificial culture. The methods of artificial cultivation need still to be worked out; and once they are discovered it is a safe prediction that control over the diseases produced by ultra-microscopic parasites will be quickly increased. The degree of infectivity of certain of the parasites—or viruses, as they are also called—is almost fabulous. One thousandth of a cubic centimeter of a filtered 2.5 per cent. suspension of a spinal cord of a paralyzed monkey suffices to cause infection and paralysis in another monkey; 0.020 of a cubic centimeter of infected lymph suffices to produce foot and mouth disease in a healthy calf, and the blood of fowl suffering from chicken plague is still active after being diluted 1,000 million times with water.

Three affections of human beings are contained among the eighteen diseases caused by filterable viruses: They are yellow fever, dengue and poliomyelitis. With one exception, the mosaic disease of tobacco, the remaining fourteen are maladies of domestic animals and include among them foot and mouth disease, horse-sickness, cattle-plague, sheep-pox, rabies,

vaccinia, hog-cholera and chicken-plague. We can at present form no reliable conception of the biology of this class of parasite, although the virus of pleuropneumonia shows affinities with the bacteria, while that of yellow fever that passes a stage of its existence in mosquitoes probably belongs to the protozoa. It should be remembered that we possess no criterion of their presence other than the power to produce infection. Probably the list of these pathogenic parasites would be increased if methods were known for testing their symbiotic relations or cooperative effects with the usual bacteria and protozoa. Rous's[11] discovery of a filterable agent that causes sarcomatous tumors in the fowl has opened up new fields to exploration. We can make a rough guess as to their sizes since some pass through thick filters, the pores of which are smallest, while others pass the more porous filters with larger interstices only. Were the viruses as large as one fifth the size of the influenza bacillus, they would be beyond visibility with the most powerful optical system of the modern microscope. The dark-field microscope and the instrument devised for employing, for photographic purposes, the ultraviolet rays of the spectrum, that has doubled the potential power of the microscope, have failed to bring them into view. On the whole they resist drying well and show considerable resistance to disinfecting agents.

The ultramicroscopic viruses employ no single means of effecting entrance into the body. Some utilize insects to inject them into the blood. Mosquitoes inoculate the parasites of yellow fever and of dengue in man, and the virus of horse-sickness among animals; while flies inject the virus of parrot-fever; and worms and other insects, through close contact with infected and then with uninfected tobacco plants, disseminate the parasite of mosaic disease. The viruses of rabies, vaccinia and fowl-pox gain entrance through skin wounds, those of hog-cholera, foot and mouth disease and chicken-plague, by swallowing, while the parasites of variola and of pleuropneumonia are inhaled with air. These are the main avenues but not the sole routes of infection, since viruses that ordinarily enter the body by the respiratory mucous membrane may occasionally enter through a skin abrasion, etc.

It is significant that upon recovery from this class of infections a high and enduring degree of immunity is left behind. We have no knowledge of toxic substances, in the common sense, being produced by the filterable viruses, and therefore know nothing of the formation of antitoxins or bodies that neutralize poisons. The principles upon which the immunity depends appear to be chiefly microbicidal or substances that act directly upon the living parasites and destroy them. In some instances it has been possible to produce an actively immune state without at the same time causing severe disease, by employing for inoculation modified and weakened viruses and viruses combined with immune sera carrying the corresponding microbicidal substances. Once a certain active immunity is obtained it can be heightened by repeated injections of more active materials until a high degree is achieved. In the same manner immune animals that have recovered from disease are capable of having this immunity reinforced by subsequent injections of the active virus. Blood taken from the immune animals has been employed in practise in two ways: to protect for a brief period exposed animals from acquiring infection, and to bring

[11] Rous, *Journal of Experimental Medicine*, 1911, XIII., 397; *Journal of the American Medical Association*, 1911, LVI., 198.

about an actively immune state through inoculation with adjusted mixtures of virus and corresponding immune serum. The injection of viruses into animals not themselves subject to infection has, in a few instances, yielded immune sera. In this way a serum for foot and mouth disease has been prepared in the horse. Speaking generally, homologous sera are more active than heterologous, or, in other words, an immune cattle serum will act better in cattle than will immune horse serum; but curative sera in a real sense have not yet been produced for this class of diseases.

It is of great interest to determine the correspondence between the general data I have just reviewed and the special facts of poliomyelitis which have been shown to arise in consequence of an invasion of the nervous tissue by an ultramicroscopic or filterable virus. We may proceed to check off rapidly the main facts. The virus stands midway in point of size between the finest and coarsest examples. It passes readily through the more coarse and slightly through the finest filters. It is highly resistant to drying, and to light and chemical action. In dust, especially within protein matter, it survives weeks and months; in diffuse daylight indefinitely, and resists the action of pure glycerine and carbolic acid in 0.5 per cent. solution for many months. When animal tissues containing the virus suffer softening and disintegration or disorganization by mould, the virus survives. Recovery from poliomyelitis in man and the monkey is attended and produced by an immunization of the body. During this process microbicidal substances appear in the blood that are capable of neutralizing the active virus. This acquired immunity has, in the monkey, been reinforced by subsequent injection of large quantities of the living virus. Active immunity can be achieved by first injecting minute and later large amounts of the virus, and an adjusted mixture of immune serum and active virus will confer a beginning low active immunity capable of being heightened. Certain alien large animals, among which the horse and sheep are especially worth mentioning, are subject to immunization through injections of emulsions of the spinal cord and brain of paralyzed monkeys, and can thus be made to yield sera possessing microbicidal power and capable of conferring, as do human and monkey immune sera, a degree of passive immunity. Thus far no immunizing effect has been accomplished with the dead virus. Unless some growth and multiplication take place no immunity arises.

These facts show a close correspondence between the properties of the virus of poliomyelitis and those of the ultramicroscopic organisms in general. There remain to be considered the data bearing upon the manner of entrance of the poliomyelitic virus into the body or, in other words, upon the mode of infection. Analogy with other diseases produced by filterable viruses excludes no one of the possible modes, since their manner of entrance is widely varied, as we have seen. This question is of the utmost importance, since with all diseases prevention is far better than the most perfect cure, and for poliomyelitis there exists at present no specific or true curative treatment. Moreover, for the most part when the disease is first recognized it has already caused irreparable damage, and though the more general examination of the spinal fluid obtained by means of lumbar puncture for purposes of diagnosis may possibly lead to a much earlier recognition of the disease, yet its

prevention will always remain the result to be aimed at. It is quite certain that an understanding of the mode of infection would lead inevitably to the framing of measures of prevention that with reasonable certainty could be expected to exercise control over the epidemic spread.

Two answers may be returned to the question: one based upon observation of human cases of poliomyelitis, and the other based upon experimental tests arranged to elicit specific replies. The first answer can not achieve anything higher than strong probability; the second, to be valid, must explain the phenomena attending the human infection as well as those of the experimental disease. We are asked to account for certain data, of which the following is a brief statement. Epidemic poliomyelitis is preeminently a disease of early childhood and finds the highest percentage of its victims in the first five years of life, but does not wholly spare older children or even adults. It is admittedly infectious; and while it is true that many more instances of single than of multiple cases occur, yet multiple ones are not by any means rare. The prevailing views on this topic are being modified rapidly by the recognition of the abortive and ambulant examples of the disease. The period of greatest prevalence is during the months of August, September and October in the northern hemisphere, and the corresponding months in the southern hemisphere, but the epidemic begins in the early spring and summer months and the disease does not wholly disappear during the winter months. It does not, therefore, necessarily die out at any period of the year. In endeavoring to trace the avenue of entrance of the virus into the body certain facts regarding its distribution in the body should be recapitulated and considered.

The infectious agent of poliomyelitis attacks chiefly the central nervous system. Indeed, it has been detected regularly in the spinal cord and brain and in the mesenteric lymph nodes among all the internal organs. It has also been detected in the mucous membrane of the nose and throat, and in the mucus secretions of this membrane, and in the mucus secretions of the stomach, and the small and large intestine. The virus has not been detected in such important organs as the spleen, kidneys, liver or bone marrow. The fact is significant, but in attempting to interpret it, account should be taken of the circumstance that at present we possess one means only of detecting the virus, and that is its transmission to monkeys, in which it produces characteristic paralyses and anatomical changes. On this account small quantities of the virus may conceivably escape discovery. However, the conclusion is none the less inevitable that detectable amounts of the poliomyelitic virus exist only in the few situations and organs mentioned. The distribution of the virus is identical in human beings, the subjects of the so-called spontaneous poliomyelitis, and in monkeys, in which the experimental affection is produced. Nor does it matter how the experimental inoculation is accomplished and whether the virus is introduced by injection into the brain or large nerves or subcutaneous tissue or peritoneum, or whether it is merely applied to the nasal mucous membrane, which, it should be emphasized, next to direct intracerebral injection, affords the surest means of causing the experimental disease. In whatever way the infection is produced purposely, the distribution of the virus in infected monkeys is the same as in infected human beings.

The virus is one that is not known to increase aside from the infected body, and

hence in order that it shall be capable of propagating poliomyelitis, it must secure a means of escape from the infected animal. The escape is now known to occur along with the secretions of the nose and throat, and the discharges from the intestine. We are obliged, therefore, to ask ourselves what the means are by which the virus confined within the interior reaches these external surfaces of the body.

Let us begin by disregarding for the moment the essential point of the way in which the virus probably enters the body in infected human beings, and give our attention to the way in which it escapes in the infected monkey into the nose, throat and intestines. We may first consider the instance in which the virus is deposited in the brain, in which it becomes sealed, as it were, and cut off apparently from the exterior of the body. Having been injected into the brain, the infectious microorganism constituting the virus multiplies both within and about the brain tissue at the site of inoculation. As multiplication progresses, the virus leaves the original site of injection and wanders through adjacent and distant parts of the central nervous tissues, becoming implanted in the medulla, the spinal cord and the intervertebral ganglia, as well as reaching the pia-arachnoidal membranes, or meninges, in which it also spreads. Ultimately, when the virus becomes sufficient in amount, it brings about anatomical changes in the nervous system, one of the results of which is paralysis. The period intervening between the inoculation and the appearance of paralytic symptoms may be as brief as two or three days, or as long as three, four or five weeks. The great disparity in this period depends upon the amount and quality of the virus, as well as the degree of resistance of the inoculated monkey.

The virus, which has found its way to the meninges, does not long remain in the cerebrospinal fluid, with which it escapes in part into the blood, where it does not appear to undergo any further increase in amount, and indeed seems even incapable of surviving for long. A part also of the virus contained within the cerebral fluid escapes regularly by way of the lymphatic channels surrounding the short nerves of smell that pass from the olfactory lobes of the brain to the mucous membrane of the nose. It has long been known that there is an intimate connection between the lymphatic vessels of the nasal mucous membrane and the lymphatic spaces of the pia-arachnoidal membrane. The virus once having gained the mucous membrane of the nose may even escape into the mucus secretion, with which it is carried into the mouth, and in part swallowed, or it may become established in the substance of the nasal membrane, where it undergoes subsequent multiplication and increase. As a matter of fact both these things occur. The virus escapes with the secretions partly externally to the infected body, and a part of it is swallowed with the secretions themselves, while a persistent infection of the secretions is maintained by means of the increase that takes place in the membrane itself. In this way is assured the escape of the virus directly into external nature, as well as the contamination of the gastro-intestinal cavity, with the discharges of which it becomes commingled. Once implanted upon the intestine multiplication not improbably continues for a time, and another source of invasion of the body is thus afforded the parasite. From the intestine it reaches in some amount the mesenteric lymph nodes, and thus enables us to account for the occurrence of the virus in those lymphatic

nodes which thus form a notable exception to the general internal organs of the body.

We have now followed the route by which the poliomyelitic virus, implanted within the apparently closed cavity of the skull, reaches the exterior of the body. It is obvious that in the spontaneous form of the infection in man no such mode of introduction of the virus can occur. The virus must indeed enter the human body by some external channel, after which it seeks and becomes implanted upon the central nervous system. It is known that in monkeys the virus is incapable of passing the barrier of the unbroken or slightly abraded skin, of being taken up from the stomach or intestine unless the functions of these organs are previously disturbed and arrested by opium, and it is further known that it traverses with difficulty or even not at all the substance of the lungs. On the other hand, it is established that the virus passes with readiness and constancy from the intact or practically intact mucous membrane of the nose to the central nervous system.

To illustrate this point I wish to describe briefly an experiment. The spinal cord of a paralyzed monkey always contains the virus we are considering. If a camel's hair pencil or pledget of cotton is covered with some of the broken up tissue of such a cord and painted upon the mucous membrane of rhesus monkeys, these animals will develop in due time the paralysis and other symptoms of poliomyelitis. Hence the virus enters the body from this surface even though no gross injury has been inflicted upon the membrane. We should now ask ourselves if the virus actually ascends to the brain by the direct path of the olfactory nerves or indirectly after first entering the blood. This is the same question that has been buffeted about in regard to epidemic meningitis. The meningococcus is found in the nasal mucous membrane of persons in contact with cases of meningitis, and in the sick themselves. It is not disputed that the meningococci settle on this membrane, but opinion is divided as to whether it goes at once to the membranes of the brain or first penetrates into the blood. To produce meningitis in monkeys it does not suffice to inoculate the nasal membrane; the meningococci must be injected into the membranes themselves. But so inoculated they escape in part along the nerves of smell into the nose. The virus of poliomyelitis is so active that implantation in the nose does suffice to cause infection. If a monkey is sacrificed about forty-eight hours after an intranasal inoculation, and the brain and spinal cord are removed and then the olfactory lobes and portions of the medulla and spinal cord are separately inoculated into other monkeys, infection is produced by the olfactory lobes alone, since in this brief period the virus has not yet reached other and more distant parts of the nervous organs. Were the virus distributed by the blood, the medulla and spinal cord would have become infective, rather than the olfactory lobes, since they exhibit a greater selective affinity for the parasite. The conclusion, therefore, is unavoidable that the virus ascends by the nerves of smell to the brain, multiplies first in and about the olfactory lobes and, in time, passes, as I believe, into the cerebrospinal liquid which carries it to all parts of the nervous organs. We have already learned that the virus can pass along a large nerve, such as the sciatic, which carries it first to the lumbar cord, whence it ascends to higher levels; we need not, therefore, be astonished to find that it can wander along the olfactory nerves and then descend to

lower levels. The large peripheral nerves are prevented anatomically from becoming infected in nature, while the small olfactory filaments are advantageously placed to act as the means of transportation. Hence the view I desire to place before you, that the nasal mucous membrane is the site both of ingress and egress of the virus of poliomyelitis in man. Support for this view is found also in the study of the microscopic changes in the meninges and the central nervous tissues. Since the virus survives in the dried state it may be carried in dust; and in one instance it has been detected in sweepings from the room occupied by a person ill with poliomyelitis.[12] Its distribution as spray in coughing and speaking is readily accomplished, and by this means both active cases and passive carriers may conceivably be produced. Still one link in the chain of causation of poliomyelitis as here outlined remained to be forged. The clinical evidence is strong in suggestion that human carriers of the poliomyelitic virus exist. The virus has now been detected in the secretions of the nose, throat and intestine of persons suffering from abortive or ambulant attacks of poliomyelitis.[13] The unrecognized examples of the abortive disease play a highly important part in the dissemination of the virus, through which the area of infection is extended, and the number of the attacked increased. A similar part has been accorded by clinical observation to the healthy virus carrier, and the healthy carrier is the last to be detected, and his existence confirmed experimentally. The obstacles in the way of this confirmation are considerable but not insuperable.

[12] Neustaedter and Thro, *New York Medical Journal*, 1911, XCIV., 813.

[13] Kling, Wernstedt, and Pettersson, *Zeitschrift für Immunitätsforschung, Originale*, 1911–12, XII., 316.

It is to be remembered that we possess no means of discovering the virus except that of animal inoculation. Should the experimental results arising from the inoculation of the secretions of the nose and throat of such healthy carriers be confirmed the evidence for the mode of infection as here outlined would be complete. The membrane of the nose and throat is far more vulnerable in young individuals, whence arises the greater prevalence during childhood of those diseases the causes of which seek this avenue of entrance into the body. Among them are included diphtheria, measles, scarlet fever and meningitis.

Would the establishment of the respiratory avenue of entrance of the virus exclude all other modes of possible infection? By no means. Plague bacilli are known to be inoculated into man by rat fleas; but the pneumonic form of the plague is admittedly caused by respiratory inoculation. Diphtheria arises upon the mucous membrane of the throat, but can develop in a wound of the skin; the virus of smallpox enters by way of the throat and nose, but can enter by a skin abrasion; the virus of foot and mouth disease is taken in with food, but produces infection when injected into the skin. Hence at the moment while knowledge is still recent and not yet perfect the too absolute adherence to one point of view is to be avoided.

Indeed, the preponderance of cases in the late summer and autumn months early suggested an insect carrier of the infection. House flies can act as passive contaminators, since the virus survives upon the body and within the gullet of these insects. It has not proved possible thus far to infect the common varieties of mosquito and the body and head louse, while success has resulted in one instance in producing infection in bedbugs which were made to feed

upon the blood of inoculated monkeys. The virus remained alive within these insects for a period of many days. The inoculation of monkeys with a filtrate prepared from them gave rise to characteristic paralysis and anatomical lesions. This result is significant, since it shows that insects are capable of taking up the virus from the blood where it exists in minimal quantities and in harboring it for a considerable period in an active state; but it does not show that multiplication occurs within them or that in nature they act as the agents of inoculation. A tentative announcement has been made recently by Rosenau[14] that the stable fly (*Stomoxys calcitrans*) can take up the virus from the blood of infected monkeys and reinoculate it into healthy ones which will become paralyzed. The experiment awaits confirmation and, after confirmation, convincing application to the circumstances surrounding infection in human cases of poliomyelitis.

The frequent prevalence of epidemics in sparsely populated country districts has led, moreover, to consideration of domestic animals as sources of the infection. Paralysis of dogs, horses, pigs and fowl has been observed, not uncommonly, but thus far without clear correlation with paralysis in man. Perhaps the most frequently observed coincidental paralytic diseases have been between hens and human beings. Undoubtedly since the wide prevalence of epidemic poliomyelitis, the existence of a paralytic disease among barnyard fowl has been more commonly noted. Possibly the condition has not actually become more frequent, but owing to the circumstance mentioned it has been oftener observed. It appears that the paralysis among fowl is caused not by lesions of the central nervous system, but by lesions of the peripheral nerves and is due to a peripheral neuritis. It has not been found possible to transmit by direct inoculation the paralytic disease from chicken to chicken, or from chicken to monkey, or from paralytic monkey to chicken. However, it has been found possible to develop the paralysis in the laboratory by keeping the chickens in confinement for some time, and by supplying them an unusual and improper form of food. It has proved as little possible to transfer the paralytic affection of dogs from one individual to another by direct inoculation, or from dog to monkey, or from paralyzed monkey to dog, or to set up paralysis in monkeys by inoculating them with nervous tissue obtained from paralyzed pigs, or to produce paralysis in pigs with the virus of paralyzed monkeys. These failures do not, of course, exclude the possibility that a reservoir for the virus may exist among domesticated animals that do not even respond to its presence by developing paralysis or other conditions which could be recognized as resembling poliomyelitis in man. The manner of action of the virus of poliomyelitis in rabbits provides an illustration which shows how necessary it is to avoid general deductions in this field. At first it was strenuously denied that rabbits could be infected at all with the virus of poliomyelitis, and the examples of supposed successful inoculation reported were entirely disbelieved; but it must now be accepted that young rabbits occasionally, but by no means generally, are subject to inoculation with the virus of poliomyelitis, at least after it has passed through a long series of monkeys. Apparently a small percentage only of the inoculated rabbits develop any obvious symptoms, and these die, as a rule, during

[14] Rosenau, communication at the International Congress of Hygiene and Demography, Washington, 1912.

convulsive seizures which come on suddenly. A given virus has up to the present been sent through a series of six rabbits, after which it has failed to be further propagated. From the sixth series it has been reimplanted on the monkey, in which animal typical paralysis has been produced. It remains to add that the rabbits which succumb to the inoculation do not show any characteristic alterations of the central nervous system or other organs, as far as has been determined. The monkey, on the other hand, invariably shows the typical lesion of the central nervous system.

Long before epidemic poliomyelitis had the wide distribution or claimed the attention now accorded it, instances of infantile paralysis were known to every one. Almost every community could point to one or more examples of the condition and no one entertained the suspicion that the cause of the paralysis was an infectious or even contagious disease. Are these isolated cases of paralysis occurring among infants of the same nature as the epidemic paralysis, or has there merely been a confusion of names? We possess means that permit an answer to this important question. Recovery, as you recall, is associated with enduring immunity and the person or animal immune to poliomyelitis carries in his blood principles that neutralize the virus causing the disease. The blood of normal persons or animals lacks this property in any real degree. The test is, therefore, easily made: a mixture of the serum of the blood and virus are prepared, and after being in contact for a time is injected into a monkey. Thus it has been determined that the two diseases are caused by the same parasite, and it has been found that the neutralizing principles are still present as long as twenty-five years after the attack of paralysis and doubtless persist through life. This test has been employed likewise to identify abortive cases of poliomyelitis in which paralysis has not appeared at all.

There is nothing unique in this apparently paradoxical situation. Most, if not all, epidemic diseases prevail at some time as sporadic affections; that is, as diseases of occasional occurrence. This is true of influenza, plague and particularly of meningitis, with which poliomyelitis displays so many affinities. Knowledge is still very imperfect as to just what happens when an epidemic spread of a sporadic disease takes place. Sometimes conditions arise that favor rapid transference of the infecting microbe from individual to individual through which a rise in virulence is accomplished very much as is done every day in the laboratory to enhance the potency of cultures. In respect to poliomyelitis, as seems also to be the case with meningitis, a fresh importation of an already enhanced virus probably occurs and is the immediate cause of the epidemic. The introduction may be at one point or at several points simultaneously, according to where the epidemic arises, and spreads from a single center or from many foci. Finally, sports, or abnormally virulent parasites, appear, prevail actively for a period and then become reduced to an average degree of intensity perhaps never to rise again. Some of the exceptionally severe epidemics of which history tells us may be thus accounted for. Such sports have been encountered in laboratories in regard to both pathogenic bacteria and protozoa.

Are biologically different strains of a poliomyelitic virus known? The evidence at hand is to the effect that different strains or races certainly exist if virulence be taken as the measure. German, Austrian and French pathologists found that

of the human specimens of spinal cords submitted to them for study about one half could be inoculated successfully into monkeys and less than this number could be propagated through successive animals. In America all the original specimens were successfully inoculated, but certain samples were far less active than others. At the beginning many of the inoculated monkeys survived the infection, sometimes with, sometimes without enduring paralysis of leg or arm. Later, fewer survived, and after many passages of the virus from monkey to monkey all became infected and all succumbed. The Swedish virus of 1911 appears to be the most powerful yet studied. This is indicated by the fact that saline washings of the nose and throat and intestine could be inoculated successfully, after removal of all bacteria through filtration, in nearly every instance.[15] In America it has been difficult to procure infection with these materials, from which it has been concluded that the virus displays a degree of infectiousness for monkeys. There are reasons for supposing that similar variations exist for man.

We may not, and probably shall not know certainly whether this variability is restricted to the quality of virulence or whether true types or races of the virus exist until artificial cultivation has been accomplished. Bacteriology has been singularly enriched recently by discoveries relating to biological types of certain microbes; and practical medicine is destined to benefit largely by the strong light which they have thrown upon perplexing questions of specific therapeutics. I am tempted to lead you aside a little way into this subject just because it is so full of suggestion and promise, and not merely with promise, since the fruits of discovery are being already tasted.

[15] Kling, Wernstedt, and Pettersson, *loc. cit.*

The pneumococcus causes many kinds of inflammation and one typical disease that prevails everywhere, namely, acute lobar pneumonia. Not infrequently there attend the pneumonia, and sometimes there appear independently such inflammations as peritonitis, pleuritis and meningitis, caused also by the pneumococcus. Now pneumococci possess in common biological features regarded usually as sufficient to distinguish them; namely, form, staining properties, growth, virulence and solubility in bile salts. But they have another quality that serves to distinguish them more finely, revealing different types among apparently similar organisms. By testing pneumococci from many different sources against an immune serum prepared with a single kind of the coccus, it has been found that the cocci are not all alike but that a predominant type and several subsidiary types occur in nature.[16] Such a serum prepared with a given type of pneumococcus is neutralizing for that one alone, and for no other. The clinical reports on the antipneumococcus serum employed as a curative agent are contradictory, and one cause for this is now apparent.

Pneumococcus meningitis can be produced in monkeys by injecting subdurally, by lumbar puncture, a virulent culture of pneumococcus; it is invariably fatal. Antipneumococcus serum alone injected subdurally can change the outcome very little. But this infection is subject to combined chemo- and serum-therapy in which the chemical agent consists of sodium oleate that alone attacks and dissolves the pneumococcus. Acting separately, in the body, sodium oleate can accomplish little; it re-

[16] Neufeld and Händel, *Zeitschrift für Immunitätsforschung, Originale*, 1909, III., 159; *Arbeiten aus dem kaiserlichen Gesundheitsamte*, 1910, XXXIV., 293; *Berliner klinische Wochenschrift*, 1912, XLIX., 480.

quires the assistance of the immunity principles. Acting together the two agents quickly bring the infection under control and recovery follows. This happens even after the pneumococci have entered the blood stream and begun to multiply there. The effects of the soap and serum compound are, however, restricted to the type of pneumococcus represented by the immune serum in the mixture.[17] When the type of microorganism and serum differ absolutely no therapeutic action follows. This obstacle to the practical employment of this method of specific treatment will doubtless be reduced or even wholly set aside by preparing a true polyvalent immune serum that will represent not many cultures of the pneumococcus taken at random, but the several types or races occurring in nature. We already know the number to be few.

It has become the custom to speak of these types of microbes as resistant or "fast"; but the term is relative merely. The fact and degree of fastness will be revealed by the source of the test-serum. But within a given microbic species this quality of resistance may well appear against chemical bodies as well. Pneumococci, for example, vary in properties by gradual gradations in the direction of the streptococcus, which besides differing in still other biological properties chances not to dissolve in bile. The gradients of pneumococci approaching the streptococcus are progressively less acted upon by sodium oleate. The trypanosome of sleeping-sickness is less subject to the therapeutic action of certain organic arsenic compounds in some regions in Africa than in others. The antimeningitis serum suppresses the growth and multiplication of most meningococci, but not of all. This quality of fastness is not alone innate but can be developed artificially as a mutation, both against serum principles and chemical drugs and may persist. Infectious diseases showing a strong tendency to relapse in course of recovery are caused by microbes tending to flourish as races or types. Relapsing fevers that pass three or four exacerbations on the way to recovery are attributed to spirochetæ assuming a corresponding number of distinct forms. Infections tending to many relapses, of which lues is an example, are attributed to parasites capable of flourishing in many such types of which one part is innate and the other the result of mutations under the influence of curative serum or drug. Fortunately, there appears to be no parasite capable of performing indefinite mutations; and experience is teaching that the more precise, specific and vigorous the means employed to control infection, the smaller the risk of mutation and the greater the probability of suppression of the parasitic agent of disease.

In 1886 Theobald Smith[18] first clearly pointed out that the injection of dead bacteria conferred active immunity to subsequent inoculation with virulent materials. Now the employment of dead bacteria is widespread both for preventing and for healing disease. Wright[19] especially is to be credited with the general application of the method to therapeutics. While the limits of value of inoculation, as it is termed, are not yet defined and it promises, theoretically, more for the subacute and chronic than for the acute infections, I am inclined to the belief that to be really effective attention will need more and more

[17] Lamar, *Journal of Experimental Medicine*, 1911, XIII., 1; 1912, XVI., 581.

[18] Salmon and Smith, *Proceedings of the Biological Society of Washington*, 1884–86, III., 29.

[19] Wright, *Proceedings of the Royal Society of Medicine*, 1909–10, III., Supplement, 1.

to be accorded to the question of specific type in the infecting bacteria.

In pursuing the devious courses of infection, of which examples have just been given, the fact has emerged that the effectiveness of curative means will be determined not only by the intrinsic qualities of the parasites but also in a high degree by the manner of location and distribution of the parasites themselves within the infected host. Whether they have a general distribution throughout the blood and tissues or whether they are confined within an important organ or part may be the factor determining the ease with which they can be reached not only by the natural curative principles of the body but also by artificial curative agents introduced into the body.[20]

The parasite, struggling to survive, withdraws, at one time, into situations to which the curative substances gain access imperfectly and with difficulty, causing thereby local infections more or less cut off from the general circulation and the curative substances purveyed by the blood. This is the condition met with in focalized inflammation and in infections of specialized portions of the body, such as the great serous cavities that receive a modified and dilute lymph secretion carrying reduced quantities of the protective principles contained within the blood. The quality of lymph in the several serous cavities and in the various tissues is not the same, and the lowest limit of strength is reached by the cerebrospinal fluid that functions as the lymph of the brain and spinal cord. The exclusion of dissolved substances from the cerebrospinal liquid is a provision of great importance, but is not an unmixed good. For while it affords protection to the sensitive nervous tissues from injurious chemicals, it deprives them also of curative principles. Happily this deficiency has now been superseded by a method of direct local treatment by injections that has given excellent results in meningitis, but is now being employed in luetic affections of the meninges and central nervous organs with encouraging results.[21]

Remote as some of them may seem, the considerations to which I have called your attention have a bearing more or less vital upon the problem of a specific and effective treatment of poliomyelitis. Poliomyelitis is not a disease with a very high mortality; its chief terror lies in its appalling power to produce deformities. When death does occur it is not the result, as in many infections, of a process of poisoning that robs the patient of strength and consciousness before its imminence, but is caused solely by paralysis of the respiratory function, sometimes with merciful suddenness but often with painful slowness, without in any degree obscuring the consciousness of the suffocating victim until just before the end is reached. No more terrible tragedy can be witnessed.

I have already laid before you certain facts regarding immunity in poliomyelitis and it remains to be added that the employment for treatment of the immune serum, taken from monkeys or from human beings, exercises a definite if not very strong protective action upon inoculated monkeys. Either the disease is prevented altogether or its evolution is modified in such a manner as to diminish its severity. When the virus used for inoculation is highly adapted to the monkey and thus very virulent it is more difficult to control the result than when it departs less from the original human type and is less active.

[20] Flexner, Simon, *Boston Medical and Surgical Journal*, 1911, CLXV., 709; The Harben Lectures, *Journal of State Medicine*, 1912, XX., 130, 193, 257.

[21] Swift and Ellis, *New York Medical Journal*, 1912, XCVI., 53. Wechselmann, *Deutsche medizinische Wochenschrift*, 1912, XXXVIII., 1446.

The immune serum has thus far acted best when it was injected into the subdural space on several successive days. This is in conformity with the fact that however introduced into the body the virus establishes itself in communication with the cerebrospinal liquid where it propagates for a time. Later the virus localizes in the nervous tissue itself and becomes accessible not from this liquid only but, probably, from the general blood also. The serum introduced into the subdural space soon escapes into the blood; and thus a double action is secured: on the one hand, it reaches the nervous tissue directly from the cerebrospinal liquid, and on the other indirectly with the blood. An immune horse serum at first gave disappointing results but latterly its employment by intramuscular injection has given more promise. But none of the sera mentioned can be regarded as having more than touched the fringe of the problem of a cure for the disease.

Such brilliant success has been recently recorded in respect to the specific chemical therapeutics of infection that an effort has been and still is being made to attack the problem from this quarter. Here also only a starting point has been secured and the subject merely opened to further experimentation. The point of departure, which we have adopted, is the drug hexamethylenamin (urotropin) which possesses a degree of antiseptic action in the body and is known to be secreted into the cerebrospinal liquid. When the drug is administered by mouth it can be detected by chemical tests in the liquid in a short time. When inoculation of virus and administration of the drug are begun together and the administration continued for some days afterward, the development of the paralysis is sometimes but not always averted. Hexamethylenamin lends itself to modifications by the addition of still other antiseptic groups to its molecule. We have tested a large number of such modifications and have found certain ones to exceed the original compound in protective power, and others to promote the onset of paralysis. This is the common story of drugs. None are wholly without some degree of injurious action upon the sensitive and vital organs of the body. But manipulative skill has already succeeded in eliminating the objectionable and improving the valuable features of certain drugs so that they exert their action but little upon the organs and severely upon the parasites when they become useful as therapeutic agents. This process may be called sundering the organotropic and parasitotropic effects. Whether this can be successfully accomplished with this class of compounds can not be predicted. But if not, the quest will be transferred to still other drugs. When it is accomplished the victory will be won. By whom will the victory be won, and when? Ours is the office of story-teller and not the vision of the prophet!

In giving Huxley to science the Charing Cross Hospital School of Medicine conferred a great benefit upon the world. In imbuing him with the ideals of biological science it performed an especial service for America. For in 1876 Huxley journeyed to Baltimore to deliver the address at the formal opening of the Johns Hopkins University, at which time he outlined in essence the plan of medical education which, twenty years later, was adopted and put into practise at the Johns Hopkins Medical School. The example of this wise foundation, inspired by Huxley, has acted far and wide throughout the United States as a regenerating force upon medical education.

Simon Flexner

FACULTY PARTICIPATION IN UNIVERSITY GOVERNMENT[1]

THE present government of American universities and colleges is altogether anomalous. The president and trustees hold the reins of power and exercise supreme control, while the professors are legally in the position of employees of the corporation. In the best institutions, however, it should be explicitly recognized that the status of the professors is in practise a good deal better than could be claimed as a matter of mere legal right. In the first place, the professors hold office for life or during good behavior or till the arrival of the age for superannuation with a reasonable pension. And in the second place, in the best American universities all educational matters have been either formally or by tacit consent delegated by the trustees to the faculties for authorization and final disposition. The place of the faculty as the sole educational authority of the university may be considered established, even though in some reputable universities the board of trustees reserves the right of veto or revision. Certainly in Cornell University the supremacy of the faculty in all educational matters has been maintained for a score of years, and professorial tenure of office is permanent and secure. Furthermore, the right to absolute freedom of thought and speech for all members of the faculty has been vigorously asserted and constantly enjoyed.

It should, therefore, at the outset be candidly acknowledged that a professor who enjoys a life-tenure of office, who is absolutely free to think and speak and write what he believes to be the truth, and who is a member of a body which controls the educational administration of the university, is already in possession and enjoyment of the highest, best and most vital things which inhere in his calling and function. Yet while all this is true the professor may be dissatisfied with the other conditions under which he is compelled to do his work. And this is undoubtedly the case in America.

Compare the American professor with the scholars and scientists of Oxford and Cambridge. They are their own boards of trustees. The legal corporation of an Oxford or Cambridge college is composed of the head (president, master, or whatever other name may be given to him) and the fellows, who are the teachers of the institution; and this body fills all vacancies by cooptation. Again in the two universities with which these self-governing colleges are connected there is a similar exercise of authority by the professors, and if it is not so complete that is only because it is shared by the nonresident Masters of Arts.

Look again at a German university. The state furnishes the funds for its maintenance and development, but, subject to the very light touch of a minister of education, the government of the university is in the hands of the faculty.

What the American professor wants is the same status, the same authority, the same participation in the government of his university as his colleague in England, in Germany and in other European countries already enjoys. He chafes at being under a board of trustees which in his most critical moods he feels to be alien to the Republic of Science and Letters. Even in his kindliest moods he can not think that board representative of the university. For the university is an intellectual organization, composed essentially of devotees of knowledge—some investigating, some communicating, some acquiring—but all dedicated to the intellectual life. To this essential fact the American professor wants the gov-

[1] From the report to the trustees of Cornell University by President J. G. Schurman.

ernment of his university to conform. And he criticizes presidents and boards of trustees because under the existing plan of government they obstruct the realization of this ideal—nay, worse, actually set up and maintain an alien ideal, the ideal of a business corporation engaging professors as employees and controlling them by means of authority which is exercised either directly by "busybody trustees" or indirectly through delegation or usurpation by a "presidential boss."

What is needed in American universities to-day is a new application of the principle of representative government. The faculty is essentially the university; yet in the governing boards of American universities the faculty is without representation. The only ultimately satisfactory solution of the problem of the government of American universities is the concession to the professoriate of representation in the board of trustees or regents and these representatives of the intellectual, which is the real life of the university, must not be mere ornamental figures; they should be granted an active share in the routine administration of the institution.

How could such a reform be carried out in Cornell University?

The board of trustees of Cornell University is a genuinely representative body. That is, it represents everybody but the faculty. The state of New York is represented by the governor and other *ex-officio* trustees and also (since the recent amendment of the charter) by trustees appointed by the governor with the advice and consent of the senate. The alumni are represented by trustees whom they themselves elect, and in June last a woman was, happily, once more elected as one of the alumni trustees. And, apart from alumni and state, the general public is represented by the trustees—half of the entire body if the *ex-officio* trustees be not counted—whom the board itself elects presumably from citizens who are especially concerned for the promotion of higher education or who are particularly interested in Cornell University. The trustees thus elected by cooptation number three annually; and it is the custom to reelect these trustees when their term expires.

Now in case of the death or resignation of one of these cooptatively elected trustees, the board might, without any change in the charter, ask the professoriate to select a candidate for the vacant position and then formally elect the candidate thus recommended. This process might be repeated till the professors had designated one third of the trustees now elected by the board, and thereafter professorial representation might remain in that ratio.

For the purpose of such representation it would probably be wise and expedient to divide the professorial electorate into groups each of which should elect one trustee. Only full professors would have the suffrage as only full professors hold permanent appointments. The full professors in the graduate school might constitute one electoral group, to fill (say) the first trusteeship assigned to the professoriate. The second electoral group might be composed of the full professors of arts and of law, and the third of the full professors of science and of medicine (in Ithaca). The full professors in the two engineering colleges and in architecture would naturally form a fourth electoral group, and those in the two state colleges—agriculture and veterinary medicine—a fifth. The medical college in New York City would furnish the sixth electoral group, but the number of professors entitled to vote should perhaps be limited to those who give their entire time to the work of the institution or those who

are heads of the more important departments.

This plan would give the professors a share in the government of the university through the voice and vote of their own elected representatives, who (unless an unalterable state law forbids) should preferably be members of the faculty. But this injection of professorial trustees into the board would be a somewhat slow process, if, as is here recommended, it took effect only when vacancies occurred by death or resignation in trusteeships now filled by cooptation of the Board. There is, however, another measure of relief which could and should be forthwith adopted, and which should continue in operation whether the privilege of representation in the board of trustees be conceded or denied to the professoriate.

While the faculties of the university control educational affairs they have, under the statutes, nothing to do with the appointment of teachers, the appropriation of funds, or other business vitally connected with the life and work of the institution or the standing and efficiency of the several departments. Here, again, it is true that practise is more considerate than theory or ordinance. For in case of appointments the president makes no nominations to the board without previous conference and practical agreement with the professors in the department or allied departments concerned. The time, however, has now arrived to codify this practise and establish it as a matter of professorial right. And at the same time the right of the professors to share in other ways in the government and administration of the faculties or colleges to which they belong, and so far as practicable of the entire university itself, needs to be specifically recognized and formally confirmed.

Towards this goal the university has been gradually tending for some years past. There may not have been a distinct consciousness of it in the general mind of the academic community, but there has been a vague yearning against a background of dissatisfaction and a foreground of hope. The situation will be brought to the consciousness of itself and crystallized in and through the idea and program of professorial participation in the management and control of the university.

The plan to be proposed has the fundamental merit of every salutary reform: it is the modification and extension of an idea and organization already in successful operation. Professors sit, deliberate and vote with the trustees in the administrative boards and councils (as they are called) which manage the affairs of the university library and of the medical college in New York. The professors are elected by their colleagues for a term of two or three years, and the trustees are similarly chosen by the board of trustees. Under the statute creating these councils they are merely advisory bodies whose resolutions come as recommendations to the board of trustees or to the executive committee, but in practise these recommendations of the men selected by the board and by the faculty to keep in intimate touch with the affairs of those great departments of the university and to dispose of them in the combined light of business and educational experience, are regarded by the board as expressions of the highest wisdom available under the circumstances and are regularly approved or, if not approved at once, merely referred back in special cases for further consideration in view of some new contingency or some unforeseen bearing upon the general policy of the university.

The council of the medical college in New York City consists of the president of the university, who is *ex-officio* chairman,

three trustees elected by the board for a term of three years, and the dean of the medical faculty and two professors elected by that faculty, for a term of two years.

The president recommends that a council of substantially this type be as soon as possible established for every college in Cornell University (except the state colleges for which councils composed exclusively of trustees have already been organized). Whether the professorial members of the council outnumber, or are outnumbered by, the trustee members is not a matter of any consequence if only it be understood that this is a scheme devolving genuine responsibility upon the professors for the administration and government of their collegiate unit of the university. If these councils are in practise to be as independent of the executive committee, and even of the full board, as the medical college council in New York City, it will probably be found necessary to allocate annually fixed portions of the income of the university to the different colleges. And with the existing distribution of funds as basis this assignment should not be an impossible task.

This is a plan of partnership between trustees and professors for the government and administration of the university. It is not the German system, which has no board of trustees, nor the English system, in which the professors are the corporation, but it is a modification of the American system in which the trustees voluntarily invest the professors with a share of their own powers and functions (devolving on them corresponding responsibilities), and guarantee them the maximum of authority, independence and institutional control which seems compatible with the American idea of university organization and government.

To these councils would be assigned the duty of dealing with all business of every kind affecting the several colleges. Whatever business now comes before the executive committee or the board of trustees affecting Sibley College or the College of Arts and Sciences or any other college of the university would be taken up by the appropriate council and settled in the form of resolutions which would be sent to the trustees for final approval and ratification. In time the councils would undoubtedly be empowered by the board of trustees to dispose definitely of routine business and minor affairs reporting only their action to the trustees. But at the outset it seems wise to follow in this respect the example already established by the council of the medical college.

There are, however, two deviations which should be made from that model, if it is to be used in Ithaca, and which indeed experience shows may in time be advantageously adopted in New York. In the first place not only should the term of office of professorial members of the council be limited, but professors should be ineligible for more than one reelection. The object of this restriction is to keep the faculty in general in close touch with the council. And, in the second place, the president should be required (as he is not in the case of the medical college council) to submit all nominations for appointments to the council in order that they may be voted on and the record of the vote sent to the board of trustees. For the reform here discussed involves the surrender of power not only by the trustees but also by the president, the supreme object being to secure (by means of the representative system applied to faculties) effective professorial participation in the administration and government of the university.

The president recommends that the foregoing scheme for taking the professoriate

into partnership with the trustees in the government and administration of the university by means of college councils composed of representatives of both be adopted by the board of trustees at the earliest practicable date. Some features of the scheme may need modification, but it will be easy to determine what changes are advisable after trustees and professors have got together in councils for the transaction of the business of the different collegiate units of the university.

A further step in the same direction should also be taken at the present time. Under the existing statutes the deans of the faculties of arts and sciences and of the graduate school are appointed by the board of trustees on the nomination of the president. The faculty has indeed some voice in the matter, for it votes on the nomination of the president and sends the record of its vote to the board of trustees. But the time has arrived when the right of the faculty to select its own chief officer should be recognized and confirmed. The president recommends that the statute be amended so as to invest the faculty with exclusive power in this regard. The faculty would of course report its action to the trustees.

J. G. SCHURMAN

THE CLEVELAND CONVOCATION WEEK MEETING

THE sixty-fourth meeting of the American Association for the Advancement of Science, and the eleventh of the "Convocation week" meetings, will be held in Cleveland from December 30, 1912, to January 4, 1913. The first general session of the association will be called to order at 10 A.M. on Monday, December 30, by the retiring president, Dr. Charles E. Bessey, who will introduce the president of the meeting, Dr. Edward C. Pickering. After addresses of welcome and a reply by President Pickering, announcements will be made by secretaries. The general session will then adjourn and the sections will be organized in their respective halls. Where sections have programs, the reading of papers will begin after organization and will be continued in the mornings and afternoons of the following days. The council will meet on Monday morning, December 30, and each morning, in the council room at 9 o'clock. On Monday evening, Dr. Bessey will give the address of the retiring president, on "Some of the Next Steps in Botanical Science," to be followed by a reception to members of the association and affiliated societies.

The addresses of retiring vice-presidents before the sections will be as follows:

Vice-president Frost, before the Section of Mathematics and Astronomy: "The Spectroscopic Determination of Stellar Velocities, considered practically."

Vice-president Millikan, before the Section of Physics: "Unitary Theories in Physics."

Vice-president Cameron, before the Section of Chemistry: "The Chemistry of the Soil."

Vice-president Shimek, before the Section of Geology and Geography: "Significance of the Pleistocene Mollusks."

Vice-president Nachtrieb, before the Section of Zoology: "Section F—Is it Worth While?"

Vice-president Newcombe, before the Section of Botany: "The Scope of State Natural Surveys."

Vice-president Ladd, before the Section of Anthropology and Psychology: "The Study of Man."

Vice-president Norton, before the Section of Social and Economic Science: "Comparative Measurements of the Changing Cost of Living."

Vice-president Thorndike, before the Section of Education: "Educational Diagnosis."

Vice-president Porter, before the Section of Physiology and Experimental Medicine: "On the Function of Individual Cells in Nerve Centers."

The full program of the meeting, which will include the programs of the affiliated societies, will be issued at the beginning of the meeting and will contain announcements of public lectures, presidential addresses before the different societies, discussions and arrangements for joint meetings, together with the times of dinners, smokers and other social functions.

Cleveland is in the territory of the Central Passenger Association. Legislative acts hav-

ing reduced fares in this territory to the two cents a mile basis, the Central Passenger Association can not make a further reduction by authorizing the certificate plan. From western points special tourist fares may be obtained. The hotel headquarters of the American Association will be the Hotel Statler, recently opened, with a very large number of rooms, all having baths, at the rate of $2 a day. The hotels are all near the center of the city. Persons arriving by the New York Central lines (Lake Shore or Big Four roads) or by the Pennsylvania lines, may conveniently alight at the Union Station; street cars run from this station directly to the hotels. Those arriving by other roads should go to the city stations in order to reach the hotel district conveniently. Section K, the American Physiological Society, the American Society of Biological Chemists, the American Association of Anatomists and the Society for Pharmacology and Experimental Therapeutics will meet at the Western Reserve Medical College, which is within easy walking distance of any of the hotels named. All other sections and affiliated societies will meet at Adelbert College, Case School of Applied Science, or the Normal School, which provide abundant facilities, so that related societies can be conveniently grouped. With the exception of the Western Reserve Medical College, the buildings are all close together, so that it will be convenient to pass from the meetings of one section to those of another. These institutions are all situated about four miles east of the center of the city, on Euclid Avenue, between East 107th Street and East 115th Street. All Euclid Avenue street cars, going eastward, pass these institutions. The cars run about once a minute, and require from twenty to twenty-five minutes to go from the hotels to the colleges. The street car fare in Cleveland is three cents, with universal transfers. Luncheon will be served in one of the buildings where meetings are held, probably at the Normal School, and there are several restaurants and lunch-rooms in the vicinity of the colleges. It is thought that all attending the meetings can be conveniently served. The general headquarters will be in the main building of Adelbert College of Western Reserve University, where there will be writing and rest rooms with the usual conveniences; there will also be rest rooms in various other buildings.

There will be sent to each member of the American Association by mail, included with bill for annual dues, a white registration card bearing the name and address of the member printed thereon. It is requested that this card be brought to Cleveland by each member attending the meeting and filled in by him to indicate his Cleveland address, his section, his affiliated society connections, together with the names of visiting ladies accompanying him. After the above information has been noted on card by the member, the card should be presented to the registration clerk at the headquarters, main building, Adelbert College, in exchange for official program and member's identification button. This can be accomplished without delay and the waiting in line as at previous meetings will be avoided. Official receipts for dues are mailed to members on the same day that their payments reach the office of the permanent secretary. For their own comfort, members are urged to send their dues to the permanent secretary as far in advance of the meeting as possible. In this way they will receive their cards by mail at once and avoid the necessity of waiting in line to make payment at the meeting. Nominations to membership and letters relating to the general business of the association should be sent to the permanent secretary, Smithsonian Institution, Washington, D. C. It is strongly urged that each member should make an effort to secure the nomination of some desirable new member.

The local executive committee for the Cleveland meeting consists of Charles F. Brush, honorary chairman; Frank P. Whitman, chairman; Dayton C. Miller, secretary; Worcester R. Warner, chairman, finance committee; Miss Jean Dawson, Theodore M. Focke, Edward P. Hyde, Franklin T. Jones,

Charles A. Marple, Robert L. Short, Albert W. Smith, Harry W. Springsteen, Olin F. Tower and Frederic C. Waite. The finance committee consists of Worcester R. Warner, chairman, Edward P. Hyde and J. Robert Crouse. For all matters relating to the local arrangements Dr. Dayton C. Miller, local secretary, Case School of Applied Science, Cleveland, Ohio, should be addressed.

Members of Sections A, B, F, G, H, K and L are referred to the following ruling of the council:

Resolved, That at the annual meetings of the Association each section shall prepare a program of general interest to scientific men, which shall occupy an afternoon session, or, if desired by the sectional committee, both morning and afternoon sessions of the same day. This program shall include the vice-presidential address.

Resolved, That, as it is the policy of the Association to avoid competition with programs presented before the special national societies, the sections are recommended to arrange no programs of special papers for the annual meetings: *Provided*, that the corresponding national society meets at the same time and place.

Members of Section C, D, E and I, by reason of there being no correlative affiliated society designated to meet at Cleveland, are requested to send to the respective section secretaries information concerning papers they may desire to submit for the Cleveland meeting.

The societies meeting at Cleveland during convocation week are as follows:

American Association of Anatomists.—Meets on Tuesday, Wednesday and Thursday, December 31 to January 2, in anatomical and histological laboratories, Western Reserve Medical School. Secretary, Dr. G. Carl Huber, University of Michigan, Ann Arbor, Mich.

American Anthropological Association.—Meets from Monday to Friday, December 30 to January 3. Joint session with American Folk-Lore Society and with Section H, A. A. A. S., for presidential address on Wednesday, January 1, at 2:30 P.M. Secretary, Dr. George Grant MacCurdy, Yale University Museum, New Haven, Conn.

Astronomical and Astrophysical Society of America.—Will meet on dates to be announced. Will hold joint session with Section A, A. A. A. S., on Tuesday, December 31, 1912. Secretary, Professor Philip Fox, Dearborn Observatory, Evanston, Ill.

American Society of Biological Chemists.—Meets on Monday, Tuesday and Wednesday, December 30 to January 1. Joint session with American Physiological Society on date to be announced. Secretary, Professor A. N. Richards, University of Pennsylvania, Philadelphia, Pa.

Botanical Society of America.—Meets Tuesday, Wednesday and Thursday, December 31 to January 2. Joint sessions with Section G, A. A. A. S., and American Phytopathological Society on dates to be announced. Secretary, Dr. George T. Moore, Missouri Botanical Garden, St. Louis, Mo.

Botanists of the Central States.—Will hold short business meeting on date to be announced. Secretary, Dr. Henry C. Cowles, University of Chicago, Chicago, Ill.

American Association of Economic Entomologists.—Meets Wednesday, Thursday and Friday, January 1 to 3. Secretary, Albert F. Burgess, Melrose Highlands, Mass.

Entomological Society of America.—Meets on Tuesday and Wednesday, December 31 and January 1. Public address on Wednesday, January 1, at 8 P.M. Secretary, Professor Alex. D. MacGillivray, 603 West Michigan Avenue, Urbana, Ill.

American Federation of Teachers of the Mathematical and the Natural Sciences.—Meets on Tuesday, December 31. Secretary, Dr. Eugene R. Smith, The Park School, Auchentoroly Terrace, Baltimore, Md.

American Folk-Lore Society.—Meets on dates to be announced. Joint session on Wednesday, January 1, with Section H, A. A. A. S., and American Anthropological Association. Secretary, Dr. Charles Peabody, Peabody Museum, Cambridge, Mass.

American Association of Official Horticultural Inspectors.—Meets on Thursday and Friday, January 2 and 3. Secretary, Professor T. B. Symons, College Park, Md.

Society for Horticultural Science.—Meets on Tuesday, December 31. Secretary, Professor C. P. Close, College Park, Md.

American Mathematical Society.—Meets on Tuesday, Wednesday and Thursday, December 31 to January 2. Joint session on Tuesday, December 31, with Section A (and probably Section B). Secretary, Professor F. N. Cole, 501 West 116th Street, New York City.

American Microscopical Society.—Meets on

Tuesday and Wednesday, December 31 and January 1. Joint sessions with Sections F and G, A. A. A. S., on dates to be announced. Secretary, Professor T. W. Galloway, James Millikin University, Decatur, Ill.

American Society of Naturalists.—Meets on Thursday, January 2. Will hold symposium on "Adaptation." Secretary, Dr. A. L. Treadwell, Vassar College, Poughkeepsie, N. Y.

American Nature-Study Society.—Meets on Monday and Tuesday, December 30 and 31. Will probably hold joint session with School Garden Association of America on date to be announced. Secretary, Professor Elliot R. Downing, University of Chicago, Chicago, Ill.

Society for Pharmacology and Experimental Therapeutics.—Meets on Monday and Tuesday, December 30 and 31. Secretary, Dr. John Auer, Rockefeller Institute for Medical Research, New York City.

American Physical Society.—Meets in joint sessions in charge of Section B, A. A. A. S., on dates to be announced. Secretary, Dr. Ernest Merritt, Cornell University, Ithaca, N. Y.

American Physiological Society.—Meets on Monday, Tuesday and Wednesday, December 30 to January 1, in physiological laboratory, Western Reserve Medical School. Joint session with Section K, A. A. A. S., on Wednesday, January 1. Secretary, Dr. A. J. Carlson, University of Chicago, Chicago, Ill.

American Psychological Association.—Meets on Monday, Tuesday and Wednesday, December 30 to January 1. Joint sessions with Sections F and L, A. A. A. S., on dates to be announced. Secretary, Professor W. V. Bingham, Dartmouth College, Hanover, N. H.

American Phytopathological Association.—Meets on Tuesday, Wednesday, Thursday and Friday, December 31 to January 3. Will hold joint sessions with Section G, A. A. A. S., and with the Botanical Society of America on dates to be announced. Secretary, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

School Garden Association of America.—Will hold joint session with American Nature-Study Society on date to be announced. Secretary, Dick J. Crosby, U. S. Department of Agriculture, Washington, D. C.

Association of Official Seed Analysts.—Will hold meetings on Thursday, January 2. Secretary, Edgar Brown, U. S. Department of Agriculture, Washington, D. C.

American Society of Zoologists.—Joint meeting of Eastern and Central Branches, on Monday, Tuesday and Wednesday, December 30 to January 1. Joint session with Section F, A. A. A. S., on date to be announced. Joint meeting with American Society of Naturalists on Thursday, January 2. Secretary in charge, Dr. Winterton C. Curtis, University of Missouri, Columbia, Mo. Secretary (Eastern Branch), Dr. John H. Gerould, Dartmouth College, Hanover, N. H.

Gamma Alpha Graduate Scientific Fraternity.—Will hold annual convention, council meeting and banquet on Tuesday, December 31, 1912. H. E. Howe, recorder, Ashland, Va.

Sigma Xi.—Will hold annual convention with banquet on date to be announced. H. T. Eddy, president, University of Minnesota, Minneapolis, Minn.

SCIENTIFIC NOTES AND NEWS

It is announced from Stockholm that the Nobel prize for chemistry has been divided between M. Grignard, of Nancy, and M. Sabattier, of Toulouse, and the prize in physics to Mr. Gustaf Dalen, head of the Stockholm Gas Company. The prize in literature has been awarded to Dr. Gerhart Hauptmann, of Berlin.

Dr. Alexis Carrel, of the Rockefeller Institute for Medical Research, who has been awarded the Nobel prize in medicine, was given a reception at the College of the City of New York, on November 16. Among those who made addresses in appreciation of his work were President Taft and M. Jusserand, the French ambassador.

Professor Charles S. Minot, of Harvard University, and Professor William M. Sloane, of Columbia University, gave their inaugural lectures at the University of Berlin, on October 31. The German emperor and the empress were present at the ceremony.

A banquet will be tendered to Dr. Theodore N. Gill, associate of the Smithsonian Institution, professor emeritus of George Washington University, and a founder of the Cosmos Club, at the Cosmos Club on December 13, as a token of esteem, in affectionate commemoration of the completion of the seventy-fifth year of his age and fifty-sixth year of publication of his contributions to knowledge.

THE secretary of the interior has announced the appointment of Mr. David White as chief geologist of the United States Geological Survey to succeed Mr. Waldemar Lindgren, who leaves Washington to become Rogers professor of geology and head of the geological department of the Massachusetts Institute of Technology. Dr. F. L. Ransome succeeds Mr. Lindgren as chief of the section of economic geology of metalliferous deposits. Mr. Lindgren retains his position as one of the geologists of the survey. He will probably take up for the survey next summer the study of the Homestake mine, South Dakota, and has in view also some reconnaissance work in southwestern Arizona.

THE General Education Board of 17 Battery Place, New York City, announces that Mr. Abraham Flexner has become a member of its staff. Mr. Flexner is the author of "The American College" (1908), and of the "Bulletins on Medical Education in the United States and Canada" (1910) and "Medical Education in Europe" (1912), issued by the Carnegie Foundation for the Advancement of Teaching.

M. ÉMILE BOUTROUX, known for his contributions to philosophy, has been elected a member of the French Academy.

THE gold medal for science of the Prussian government has been conferred on Dr. Walther Nernst, professor of chemistry at Berlin.

THE Swedish Medical Society has conferred the Retzius gold medal on Dr. John Newport Langley, professor of physiology in the University of Cambridge, for his work on the nervous system.

THE Weber-Parkes prize of 150 guineas and a silver medal, founded in 1895 by Sir Hermann Weber in memory of the late Dr. E. A. Parkes, and awarded every third year to the author of the best essay on tuberculosis, has been awarded by the Royal College of Physicians to Mr. J. A. D. Radcliffe, pathologist to the King Edward VII. Sanatorium, Midhurst.

DR. JACQUES HUBER, director of the Goeldi Museum of Natural History and of the Botanical Garden of Pará, Brazil, has been visiting the scientific institutions of the United States.

WALTER SHELDON TOWER, associate professor of geography in the University of Chicago, has returned from a seven months' tour of investigation of the economic, geographic and commercial conditions of Chile, the Argentine Republic, Uruguay and Brazil.

MR. D. W. BERKY, magnetic observer of the department of terrestrial magnetism, Carnegie Institution of Washington, left Biskra, Algeria, on October 29 for a trans-Saharan trip to Timbuktu. Mr. Berky is accompanied by Mr. H. E. Sawyer, magnetic observer of the department, an interpreter and caravan party. The expedition will require from four to five months' time and it is expected much valuable magnetic data will be secured.

J. PAUL GOODE, associate professor of geography in the University of Chicago, has well advanced toward completion a series of wall maps for colleges and universities—an attempt to produce in America maps of as high quality as those of Germany.

PRINCETON UNIVERSITY has inaugurated a course of public lectures by members of the faculty on "Some Aspects of the Rennaissance." The lectures include "Philosophy," by Professor Kemp-Smith; "Natural Science," by Professor Trowbridge, and "The Medieval Mind," by Dr. Stewart Paton.

UNDER the auspices of the department of geology of Columbia University an illustrated public lecture was given by Dr. Herman Le Roy Fairchild, professor of geology in the University of Rochester on "Glacial Geology of New York State," on November 12.

PROFESSOR C. F. HODGE, of Clark College, Worcester, Mass., addressed the Science Club of the University of Wisconsin on "Fly Extermination as a Problem in University Biology," on November 6, 1912.

PROFESSOR ROBERT A. MILLIKAN, of the department of physics in the University of Chicago, who recently presented papers before the Deutsche Physikalische Gesellschaft in Berlin and the Dundee meeting of the British Association for the Advancement of Science, is

to give the annual Sigma Xi address at the University of Kansas early in November and also an address before the Kansas State Teachers' Association in Topeka on the subject of "Recent Discoveries in Physics and Chemistry."

At the annual meeting of the Kansas Teachers' Association, held at Topeka, November 7 and 8, Professors David Eugene Smith and Maurice A. Bigelow, of Teachers College, Columbia University, delivered addresses, the former on "Teaching Mathematics," and the latter on "Biology as Applied Science."

The following non-resident lecturers in highway engineering at Columbia University have been appointed for the 1912–13 session: John A. Bensel, New York state engineer; William H. Connell, chief, Bureau of Highways and Street Cleaning, Philadelphia; Morris L. Cooke, director, Department of Public Works, Philadelphia; C. A. Crane, secretary, the General Contractors Association; W. W. Crosby, chief engineer to the Maryland Geological Survey and consulting engineer, Baltimore; Charles Henry Davis, president, National Highways Association; A. W. Dow, chemical and consulting paving engineer, New York City; Walter H. Fulweiler, engineer, Research Department, United Gas Improvement Company; John M. Goodell, editor-in-chief, *Engineering Record;* D. L. Hough, president, the United Engineering and Contracting Company; Arthur N. Johnson, state highway engineer of Illinois; Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment, New York City; J. C. Nagle, professor of civil engineering and dean of the School of Engineering, Agricultural and Mechanical College of Texas; Harold Parker, first vice-president, Hassam Paving Company; H. B. Pullar, assistant manager and chief chemist, the American Asphaltum and Rubber Company; J. M. F. de Pulligny, ingénieur en chef des ponts et chaussées, et directeur, Mission Française d'Ingénieurs aux Etats-Unis; John R. Rablin, chief engineer, Massachusetts Metropolitan Park Commission; Clifford Richardson, consulting engineer, New York City; Philip P. Sharples, chief chemist, Barrett Manufacturing Company; Francis P. Smith, chemical and consulting paving engineer, New York City; Albert Sommer, consulting chemist, Philadelphia; George W. Tillson, consulting engineer to the president of the Borough of Brooklyn.

The following lectures are announced at the Royal College of Physicians, London, during November: the FitzPatrick lectures by Dr. Raymond Crawfurd on "The History of Medicine" on November 7, 12, 14 and 19, the subject being "Echoes of Pestilence in Literature and Art"; the Horace Dobell lecture by Dr. C. J. Martin, on "Insect Porters of Bacterial Infection," on November 21.

The eighty-seventh Christmas course of juvenile lectures, founded at the Royal Institution in 1826 by Michael Faraday, will be delivered this year by Professor Sir James Dewar, LL.D., D.Sc., Ph.D., F.R.S., Fullerian professor of chemistry. The lectures will be experimentally illustrated, and the subjects are as follows: "Alchemy," Saturday, December 28; "Atoms," December 31; "Light," January 2; "Clouds," January 4; "Meteorites," January 7; "Frozen Worlds," January 9. The lecture hour is 3 o'clock.

As a memorial to the late Professor Tait it is proposed to establish an additional chair of physics at Edinburgh, for which it is hoped to collect at least £20,000. The chair would be connected with the department of Tait's work in which he achieved especially conspicuous success—namely, the application of mathematics to the solution of physical problems, including those which bear upon engineering and other departments of applied science.

At a meeting held at the Mansion House to establish a memorial to Lord Lister, it was decided to put up a medallion in Westminster Abbey; to erect a monument in a public place in London; and to found an International Lister Memorial Fund for the advancement of surgery.

Dr. Oliver Clinton Wendell, assistant professor of astronomy in Harvard University, died at Belmont on the fifth instant, in the sixty-eighth year of his age.

MR. HENRY GROVES, who with his brother, Mr. James Groves, is the author of important contributions to botany, died in London on November 2, aged fifty-seven years.

DR. HEINRICH RITTHAUSEN, formerly professor of agricultural chemistry at Königsberg, has died at the age of eighty-seven years.

UNIVERSITY AND EDUCATIONAL NEWS

MR. GEORGE F. BAKER, president of the First National Bank of New York City, has given a large sum, reported in the newspapers to be $2,000,000, to bring about an alliance between the New York Hospital and the Cornell Medical College.

DR. ARTHUR T. CABOT, a fellow of Harvard University, has bequeathed $100,000 to the Harvard Medical School and the larger part of his estate, estimated at $500,000, to Harvard University, after the death of Mrs. Cabot.

ACCORDING to the accounting of the executors of the estate of George Crocker, Columbia University receives $1,566,635 for the Crocker Cancer Research Fund.

IT is announced at the University of Rochester that $262,510 has been contributed to the endowment fund by alumni living elsewhere. Dr. L. E. Holt, of New York City, gave $10,000; J. Sloat Fassett, of Elmira, $5,000, and F. R. Welles, of Paris, $12,000.

AN annual fund of $15,000 for the purpose of carrying on research work in medicine at the University of Toronto has been subscribed for five years by a few citizens of Toronto, who have become interested in medical education through the efforts of Professor Alexander McPhedran, head of the department of medicine.

MR. ANDREW CARNEGIE has offered to the University of Paris the last $20,000 necessary for equipping the new Institute of Chemistry in course of erection in the Rue Pierre Curie.

GRADUATE students in the department of botany at the University of Chicago have received the following appointments from other institutions for the present year: Joseph S. Caldwell, fellow in the department, to be professor of botany at the Alabama Polytechnic Institute; Charles A. Shull, to be assistant professor of plant physiology at the University of Kansas; Ansel F. Hemenway, to be professor of biology at Transylvania University, Kentucky; Claude W. Allee, to be instructor in plant physiology at the University of Illinois; Norma E. Pfeiffer, to be instructor in botany at the University of North Dakota, and Rachel E. Hoffstadt, to be instructor in charge of biology at Marshall College, West Virginia.

DONALD W. DAVIS, for the past three years a student in the graduate school of arts and sciences of Harvard University, has been appointed assistant professor of zoology in Clark College, Worcester, Mass.

IN consequence of the additional grant made by the London County Council to the University of London, professorships of mathematics and of civil engineering have been established at King's College. To the former Dr. J. W. Nicholson, lecturer at Cambridge, has been appointed, and to the latter Mr. A. H. Jameson, engineer of the Thirlmere aqueduct. A professorship of mathematics has also been established at Bedford College, to which Mr. Harold Hilton, of the college, has been promoted.

DR. P. EHRENFEST, of St. Petersburg, has been appointed professor of physics at Leiden.

DISCUSSION AND CORRESPONDENCE

A SIMPLE DEMONSTRATION OF THE ACTION OF NATURAL SELECTION

IN a recent presidential address, an eminent biologist referred to "such highly speculative disciplines as natural selection, Neo-Lamarckianism, neo-vitalism, etc." The criticism of natural selection implied by such association would have been quite in place a few years ago. Since it represents a widely prevailing opinion at the present time, it may not be out of order once more[1] to direct attention to the fact that natural selection is no longer neces-

[1] The progress which has recently been made by biometricians in the investigations of the selective death rate—the mortality which is not random but which is a function of the characteristics of the individual—has been reviewed in a paper,

sarily a "highly speculative discipline," but rather a field for quantitative research. Weight may be given to this statement by a brief description of an experiment made this year at the Station for Experimental Evolution.

Much of the biometric work on selective mortality has necessarily been of a highly statistical character, but this particular experiment has the virtue of extreme simplicity. In the spring of 1912, a series of about 238,000 bean seedlings was examined for morphological variations to serve as a basis for experiments in selection within the "pure line." Of these, about[2] 4,217 abnormal[3] and 5,030 normal[4] seedlings were transplanted to the field. In doing this great care was used to maintain precisely comparable conditions for both normal and abnormal plants. As plants died, from any cause[5] whatever, their labels were brought in and at harvest time a summary was prepared showing the numbers of seedlings failing to develop to fertile maturity.

Of the 5,030 normal plants, 226, or 4.493 per cent., died. Of the 4,217 seedlings showing some morphological variation from type, 286, or 6.782 per cent., failed to reach maturity.

"The Measurement of Natural Selection," appearing in *The Popular Science Monthly*, Vol. 78, pp. 621–638, 1911. Several other studies have been published since the writing of that résumé.

[2] The numbers given here are substantially correct, but may be slightly modified when the records are verified by checking against the labels of the individual plants. This can not conveniently be done until the 8,000 and more individually wrapped plants are opened for shelling and planting in the spring of 1913.

[3] Abnormal includes all morphological deviations from the normal type.

[4] For every abnormal seedling found at least one normal was taken quite at random from the same seed flat. The chief reason for the excess of normals is that in some lines the quantity of seed was not as large as necessary for securing a good number of abnormals, and in these cases normals were planted to avoid losing the line.

[5] An exception is made in the case of a large area of plants which were completely ruined when nearly ripe by obviously non-selective causes outside the experimenter's control.

Line	Death Rate of Typical Seedlings	Death Rate of Atypical Seedlings
1– 10	4.85	4.98
11– 20	5.16	7.46
21– 30	5.03	7.75
31– 40	4.59	6.49
41– 50	3.81	5.56
51– 60	6.80	8.39
61– 70	5.26	6.94
71– 80	3.30	5.88
81– 90	8.12	9.15
91–100	5.84	11.33
101–110	1.95	2.35
111–120	3.92	7.03
121–130	4.00	7.08
131–140	4.05	9.81
141–150	4.28	5.09
151–160	3.89	2.65

Thus under conditions of careful cultivation, with ample space, with no intra-specific and practically no inter-specific competition, and with a general mortality of less than 5.55 per cent. there is a clearly marked selective death rate.

Now if p be the number which perish in a population of m individuals the probable error of that number is given[6] by

$$E_p = .67749\sqrt{p \times \left(1 - \frac{p}{m}\right)}$$

From the absolute probable error, the percentage probable error is at once obtained by taking the ratio of 100 p to m. Thus we have for the death rates:

	Per Cent.
For normals	4.49 ± .20
For abnormals	6.78 ± .26
Difference	2.29 ± .33

Thus the difference is seven times its probable error, and is clearly trustworthy statistically. That it is not due to chance is most strongly brought out by splitting the material up into 16 lots of about ten "pure lines" each, and determining the death rate for normals and abnormals in each lot separately. The little table gives the results.

Because of the low mortality great irregularity is to be expected in the results. *But in*

[6] *Biometrika*, 2: 274, 1903.

fifteen out of the sixteen lots the failure is higher among the abnormal than among the normal plants.

The material is classified in only the alternative categories, normal and abnormal, or typical and atypical—of which the latter is highly complex, comprising many different morphological variations in their permutations. Possibly, some types among the atypical show a lower mortality than the typical seedlings. When materials are ample I hope to determine approximately the selective value of each of the chief types of variation, both alone and in various combinations. In the meantime, the data given here may serve to record another case of the quantitative demonstration of a selective death rate.

J. ARTHUR HARRIS

CARNEGIE INSTITUTION OF WASHINGTON

THE DOMAIN OF COMPUTATIONAL ASTRONOMY

TO THE EDITOR OF SCIENCE: In the light of Professor Campbell's criticism (SCIENCE, October 25) it is to be regretted that I did not state explicitly that the domain of computational astronomy is much larger than that of the determination of orbits. This is so obviously true that it did not occur to me that my remarks could be misinterpreted. Let me amend, therefore, with the statement that Buchholz's Klinkerfues's "Theoretische Astronomie" belongs in the general field of computational astronomy.

My remark that the computational field might perhaps be called the bookkeeping, or auditing, department of astronomy may have been "unfortunate." Since it incurred the criticism of Professor Campbell I feel quite certain it was. But there is nothing in his communication which leads me to doubt its essential accuracy.

This classification of "theoretical astronomy," which was made only in the interest of exactness, clearly does not imply any disrespect for computation which is of great value not only in astronomy but in many other subjects.

W. D. MACMILLAN

UNIVERSITY OF CHICAGO,
October 25, 1912

SCIENTIFIC BOOKS

Gould and Pyle's Cyclopedia of Practical Medicine and Surgery, with particular reference to diagnosis and treatment. Second edition, revised and enlarged by R. J. E. SCOTT, M.D., with six hundred and fifty-three illustrations. Philadelphia, P. Blakiston's Son & Co. Royal 8vo. 1912.

In our times the medical sciences make such rapid advances that medical text-books and encyclopedic works are soon out of date. It was therefore a happy idea and a meritorious work of Dr. Scott to revise and republish Gould and Pyle's valuable "Cyclopedia," which first appeared in 1900. The new edition retains the excellent features of the first and new ones have been added. The list of contributors is a guaranty of the sterling value of the book.

The work is in size and arrangement of contents very much like those eminently practical encyclopedias of Forbes (1833), Todd (1835), Tweedie (1840), Quain (1882), which differed notably from the huge German and French works of a similar character, like those of Eulenburg (1886–89) and Dechambre (1864–89), in that they condensed a very large amount of knowledge in one or two volumes. What the general practitioner wants is not a cumbersome work of reference of twenty or thirty volumes, where he has to wade through a lengthy and exhaustive exposition of a subject, but a concise presentation of the salient facts, which he can take in in a few minutes. Such a book is the one before us. It is the only medical reference book of its kind in America and it may truly be said that it fills a much needed want.

On examining the book the reader is at once struck at the large amount of knowledge compressed in such a small space. It is, indeed, the comparatively small size of the book which gives it a great advantage over similar works. The writers have succeeded in giving the essential and important points of the various subjects in the most concise form. Titles like cerebrospinal meningitis, heart-disease, infant feeding, malarial fever,

nephritis, tumors of the spinal cord, examination of urine, are presented in a most effective manner. Equally well handled are the surgical subjects. Especially worthy of mention are the titles aneurysm, gunshot wounds, hernia, surgery of the intestines, neck and stomach.

Diagnosis forms a valuable part of the work. Besides the portions on diagnosis under the various diseases such general titles as physical diagnosis of the abdomen, examination of the blood, examination of the chest and heart, pain, are presented in a concise and most interesting manner. The same observation applies to the portions which give the treatment of the various diseases.

Among the specialties the eye is especially skilfully treated. The titles cataract, cornea, glaucoma, lenses, trachoma, deserve special mention.

The work contains the latest discoveries in medicine. We find in it an account of Bier's hyperemic treatment, Brill's disease, hookworm disease, immunity, opsonines, pellagra, serum therapy. The title syphilis contains the latest additions to our knowledge of this disease; it gives a clear and concise exposition of the Wassermann reaction and of the new treatment with salvarsan.

And now we come to the defects; they are few. Some subjects are perhaps too lengthily treated, as for instance, climatology, constipation, life assurance, the latter title taking up more than six pages, which is out of proportion to the general concision of the work. We miss some titles like adalin, decompression of the brain, intratracheal insufflation, vestibular nystagmus, pantopon and a few others. But all in all the work is as complete as can be expected. The few defects are easily outweighed by the many merits the work possesses.

A number of tables of the arteries, muscles, nerves, poisons, reflexes, tumors, etc., form a valuable addition. There are 653 illustrations, those on anatomy and surgery being especially good. On the whole it may be said of this work that its defects are few, its merits many and the general practitioner will find it a valuable aid in the daily routine of his work.

A. ALLEMANN

ARMY MEDICAL MUSEUM

Genera Insectorum, 122me Fascicule. Dermaptera. By MALCOLM BURR, D.Sc. Brussels, Wytsman. December 15, 1911. Pp. 112, 9 plates.

Since De Borman in 1900 gave to the world in "Das Thierreich" his "Monograph of the Dermaptera," the number of species known to science has been doubled and the number of genera erected by various authors has been quadrupled. In 1910 Dr. Malcolm Burr published a volume upon the Dermaptera of India, Burmah and Ceylon, which was issued as one of the volumes of "The Fauna of British India" which is being printed under the auspices of the Indian government. At the time of its appearance that work was noticed by the present writer in the columns of SCIENCE. The work before us is an advance upon the former treatise in so far forth as it endeavors to outline the classification of the dermapterous fauna of the world, giving the characters of the various genera, lists of the known species, and their synonymy.

The author recognizes three suborders. The first, the Arixenina, is parasitic, and thus far is known by but one genus and species, *Arixenia esau*, described by Dr. Karl Jordan in 1909. This curious insect has the eyes only feebly developed, is apterous, and inhabits the pouch of the Javan bat *Cheiromeles torquatus* Horsfield. The second suborder, the *Hemimerina*, is likewise represented by a single genus and species. It is also parasitic, living on the widely distributed African rodent, *Cricetomys gambianus* Waterhouse. It is viviparous, apterous and totally blind. The third suborder comprises the Forficulina, or ear-wigs proper, which are oviparous, have fully developed eyes, are either winged or apterous, and have the cerci developed into horny forceps. None of them are parasitic. In the latter suborder the author recognizes three super-families, the Protodermaptera.

divided into two families in which are included fifty-two genera; the Paradermaptera, in which there is but one family, including two genera; and the Eudermaptera, divided into three families, containing seventy-seven genera.

Dr. Burr is recognized to-day as the most eminent student of this order of insects, which until recently has been somewhat neglected, but with which, thanks to his patience and learning, no entomologist need now claim ignorance for lack of adequate and authoritative treatises upon the subject. The end of Dr. Burr's labors has not, however, been reached, and he intimates that he is preparing a still more complete and elaborate work, which will deal with all known species from all parts of the world. When this task shall have been completed no order of insects will have been more thoroughly monographed than this.

The plates illustrating the present work are excellent, and with the exception of a few errors in punctuation the typography is as good as the illustrations.

W. J. HOLLAND

College Zoology. By ROBERT W. HEGNER. Macmillan. 1912. Pp. xxv + 733.

In this book "(1) Animals and their organs are not only described, but their functions are pointed out; (2) the animals described are in most cases native species; and (3) the relations of the animals to man are emphasized." The discussion of each phylum is introduced by an account of one or more types. The general plan is not unlike that in Parker and Haswell's "Text-book of Zoology." Hegner's book will, however, probably prove to be better suited to American students because it discusses types they may meet every day.

The book is progressive and up-to-date. Such topics as the recent work on the hookworm in the United States, and the investigations of the United States Department of Agriculture on bird foods are considered. Many old familiar names are replaced by more modern terms and we find *Trichinella* for *Trichina*, *Ameba* for *Amœba*, *Dolichoglossus* for *Balanoglossus*, *Anthozoa* for *Actinozoa*, *Branchiostoma* for *Amphioxus*, etc. The derivation of all scientific terms is given, and there is full citation of the authorities for figures. Few of the figures are original, but have been largely selected from other works. They are good for the most part.

Evidences of carelessness or hasty preparation appear in several places. For example, it is said that in the Metazoa, "the entoderm becomes the epithelium of the digestive tract, pharynx and respiratory tract" (p. 89)—a statement that will not hold true for all invertebrates; the aboral pole of crinoids is said to be "Usually with cirri or sometimes with a stalk" (p. 190) when the opposite is true; the eyes of the crayfish are said "to produce an erect mosaic or 'apposition image'" (p. 286), which would doubtless lead a student to believe that the two types of images were the same; on page 300 "*Cyclops*" is referred to as a species; *Branchipus stagnalis* is said to be a form of *Artemia salina* (p. 293), a view that has long been given up; *Polychœrus* is listed as a triclad turbellarian (p. 156); the pericardium is affirmed to be a part of the cœlom (p. 406). The book is remarkably free from typographical errors.

In the opinion of the reviewer this work is the best general college text-book of zoology that has been written up to the present time for use in the United States. The publishers have done their part in excellent fashion; the text is generally clear and understandable; the figures are good; and there is a fine index. The book contains many loose statements and some small errors; the writer has evidently been actuated by a desire to get out a good book *quickly* and has not always made conservative statements nor checked errors carefully. Nevertheless these defects are not serious enough to detract from the general value or usefulness of the work and it will doubtless continue to be popular for several years. A second printing has already been issued.

A. S. PEARSE

UNIVERSITY OF WISCONSIN

SPECIAL ARTICLES

THE EXPLANATION OF A NEW SEX RATIO IN DROSOPHILA

EXTRAORDINARY sex ratios have appeared at three different times in our stocks of *Drosophila*. Quackenbush described the first case.[1] Miss E. Rawls met with another case. Her results are now in press.[2] A third case has quite recently appeared in one of my other cultures not related to the last. During the past summer Miss Rawls turned over some of her stock to me. At that time some females were producing two females to one male, and other females equal numbers of both sexes.

If sex is determined by a factor in the sex chromosomes it seemed probable that some change had occurred in this chromosome. Several possibilities suggested themselves and were tested by means of the following crosses. I mated virgin females (red eyes) of Rawls's stock, in pairs, to white-eyed males. All the offspring had red eyes. Some of the F_1 females gave the 2:1 ratio. When these females were bred to white-eyed males again the following results were obtained:

Red ♀	Red ♂	White ♀	White ♂
448	2	452	374

The unusual ratio is evidently due to the almost complete disappearance of the red-eyed males, equality in all four classes being the normal expectation for this cross. On the face of these returns it seemed likely that some lethal factor must be contained in the single sex chromosome of the lost males. The lethal portion of this chromosome is derived from the red-eyed grandmother that gave the abnormal sex ratio. If this is the correct explanation, then, as the following analysis shows, all the red-eyed females in the last result should give a 2:1 ratio irrespective of the male to which they are bred. This, in fact, is the case. Similarly, the white-eyed females should give the usual 1:1 ratio; and this also proved true. The only doubtful point is the case of the two red-eyed males. If the lethal factor contained in the chromosome in question should occasionally "cross over" from the red factor, then a red-producing chromosome would result, which, if it went into a male, should give a normal male. To test this these males were united to normal females and gave normal sex ratios. The daughters of these were then tested individually and all have produced normal ratios. The explanation holds. Conversely, there are expected a few white females due to crossing over that contain the lethal factor. The chance of obtaining one is approximately 1 in 200 times. As yet this test has not been carried out. The formulas which illustrate the relation just described are as follows:

Let $X =$ the ordinary sex chromosome and χ the sex chromosome that carries the lethal factor. The factor for red eye, R, and its allelomorph for white eyes, W, are carried by the sex chromosomes. The original female that gave a 2:1 ratio would have the formula $RX - R\chi$ and the white-eyed male $WX-$. Then

$$
\begin{array}{ll}
\text{Red } ♀ & RX - R\chi \\
\text{White } ♂ & WX - \\
\hline
RX\ WX & = \text{red } ♀ \\
R\chi\ WX & = \text{red } ♀ \\
RX\ — & = \text{red } ♂ \\
R\chi\ — & = \text{——}
\end{array}
$$

Of the two kinds of red females we are concerned here only with $R\chi WX$. If she is mated to a white-eyed male the results are:

$$
\begin{array}{ll}
R\chi & - WX \\
WX & -\ — \\
\hline
WX\ WX & = \text{white } ♀ \\
R\chi\ WX & = \text{red } ♀ \\
WX\ — & = \text{white } ♂ \\
R\chi\ — & = \text{———}
\end{array}
$$

In both cases the male with the lethal factor does not develop, or dies. He does not, therefore, appear in the results except in those rare cases (the two cases above) where an interchange takes place between the sex chromosome in the female $R\chi - WX$, so that there results $RX - W\chi$.

[1] SCIENCE, 1910.

[2] *Biol. Bulletin*.

It is obvious on the other hand that half of the females also contain one sex chromosome that carries the lethal factor. They are saved by the other sex chromosome, but they will transmit the fatal dose to half of their sons who die and to half of their daughters who live.

The same test has been made with another sex-linked character, viz., miniature wings and the same results obtained. If, however, the lethal factor separates from the red-white factor (*R — W*) only once in 200 times it must be near that factor, on my hypothesis of the linear order of the factors in the chromosomes. If it does then we can calculate how often the crossing over for the wing factor should occur. In brief, we predicted the ratio of long and miniature-winged males that are expected in the back cross, *i. e.*, how many long-winged males would escape the fatal dose. The prediction was verified. For example, in F_2 there were obtained

L ♀	*L* ♂	*M* ♂
910	156	243

The number of cross-over males is 156, the number expected for the total number (399) of males is 133; this excess of long males is in the direction which the known differences in viability of long versus miniature might produce.

Similarly for the sex-linked factor for "eosin eyes." This factor lies near to the factor for red (*R*), hence in an experiment similar to the one with white eyes, red-eyed males should be rare. Up to the present time, 411 F_2 eosin males have emerged and one red-eyed male. The expectation is two red males to 400 eosin males.

T. H. Morgan

COMPLETE LINKAGE IN THE SECOND CHROMOSOME OF THE MALE OF DROSOPHILA

It has been shown recently[1] that the non-sex-linked factors that give black and wingless flies are linked to each other. In the F_2 generation (from P_1 black winged by gray wingless) there were produced:

GW	*BW*	*Gw*
2,316	1,146	737

No black, wingless flies appeared which seemed due to close linkage between the factors in question. Yet, when F_2 gray, wingless females were tested by breeding to black, winged males quite a number of black flies were obtained in the first generation (15 to 125). The explanation offered was that "crossing-over" or breaking the linkage occurred so rarely that in the production of the F_2 generation no two wingless black gametes had happened to meet.

In order to test how often crossing-over occurred, the experiment was repeated, but this time the F_1 females and males were tested for cross-overs by mating them to black wingless flies. Thus, black, winged females were mated to gray, wingless males and gave F_1 gray, winged flies. The F_1 males were tested with black wingless females and gave:

BW ♀	*BW* ♂	*Gw* ♀	*Gw* ♂
514	478	355	366

These results show that there has been no crossing-over in the F_1 heterozygous males.

The converse cross was as follows: Gray, winged females were bred to black, wingless males and produced gray, winged males and females. The F_1 males were bred, as before, to black, wingless females, and gave:

GW ♀	*GW* ♂	*Bw* ♀	*Bw* ♂
213	171	154	123

Here again the combination that went into the F_1 male remained intact.

Similar crosses in which the F_1 females were tested gave a different result: When F_1 gray, winged females (out of black, winged females by gray, wingless males) were bred to black, wingless males there were obtained:

BW♀	*BW*♂	*GW*♀	*GW*♂	*Bw*♀	*Bw*♂	*Gw*♀	*Gw*♂
696	717	305	273	180	127	606	511

The converse cross, viz., F_1, gray, winged females (out of gray, winged females by black, wingless males) were bred to black, wingless males and gave:

BW♀	*BW*♂	*GW*♀	*GW*♂	*Bw*♀	*Bw*♂	*Gw*♀	*Gw*♂
222	191	1,018	928	668	657	202	146

Adding the last two results together, it is

[1] Morgan and Lynch, *Biol. Bull.*, Vol. XXIII., p. 174, August, 1912.

found that the percentage of "crossing-over" in the female is 21.9.

These experiments make clear, first, that *there is no crossing-over in the male* (at least for the number of cases here recorded); second, that *in the female the gametic ratio is about one to four.*

The bearing of the results on the explanation of the absence of crossing-over of sex-linked characters in the male is obvious. In that case the presence of only one sex chromosome in the male made crossing-over impossible, and this was the explanation offered. But the factors concerned with black and wingless lie in a different chromosome (in the sense that they are linked to each other and not to any sex-linked factor) which is present in duplex in both sexes, yet crossing over occurs in one sex only. Whether this second chromosome is the one to which in *Drosophila* the sex chromosome is attached can not be stated, and the question must be left unsettled until we have tested the crossing-over of other factors in this and in other chromosomes.

As Mr. A. H. Sturtevant has pointed out to me, the case here recorded offers apparently an explanation of cases in plants recently described by Bateson and others.[2] When the two dominants enter from different sides no crossing over is apparent, as seen in the first case recorded above ("complete repulsion"). When the two dominants enter from the same side there is evidence of crossing over ("partial coupling"), as shown by the following example. Gray, winged females were mated to black, wingless males, and gave gray, winged F_1 offspring. These inbred produced the following F_2 classes:

BW	*GW*	*Bw*	*Gw*
9	246	65	18

These results in the F_2 generation are of the same kind as those that Bateson and Punnett have recorded for peas, etc. Back-crossing has shown in the flies that the results are due to failure of "crossing-over" in the males. If the same tests, when applied to peas, give the same result there will be no longer any need to assume, as Bateson and Punnett have done, that there is (*A*) a system of partial coupling, (*B*) a system of complete repulsion, or "spurious allelomorphism" or to assume (*C*) a system of special dichotomous ratios for coupling, such as 3 : 1 and 7 : 1, etc.

T. H. Morgan

[2] *Proc. Roy. Soc.*, Vol. 84, 1911.

THE PROBABLE RECENT EXTINCTION OF THE MUSKOX IN ALASKA

The question of the probable recent extinction of the muskox (*Ovibos moschatus*) in northern Alaska, which has often been mooted, acquires new interest through information kindly furnished me by Mr. Vilhjálmur Stefánsson, who has just returned from four years of exploration in Arctic America in the interest of the American Museum of Natural History. Under date of New York, November 2, 1912, he writes:

Dear Dr. Allen: At your request I summarize briefly my information in regard to muskoxen in Alaska secured on the museum's arctic expedition during the years 1908–12; a full statement will in due course be prepared by Mr. R. M. Anderson, who was in charge of the zoological work of the expedition.

(*a*) Information secured from natives and white residents in Alaska: During the winter 1899–1900 there died at Cape Smythe (or near there) the Eskimo man called Mangi by the whalers (probably Mangilanna). He was the last to die of Cape Smythe (Point Barrow) natives who had seen live muskoxen in that vicinity. He was probably born between 1845 and 1850, as he was able to remember Maguire's visit to Point Barrow. A few years after Maguire's time—perhaps therefore about 1858—there was scarcity of food in winter at Cape Smythe. Mangi's father then went inland looking for caribou, and some distance up the Kunk River, which flows into Wainwright Inlet, they fell in with a band of thirteen muskoxen and killed them all. Since then no one near Point Barrow is known to have killed muskoxen or seen them.

There are many places inland from Point Barrow where muskox skulls and bones are abundant. As these are heavy and there is no market for them locally, few are brought to the coast. Our party secured one skull only.

(*b*) Information based on specimens: While dig-

ging in an old house ruin about 15 miles southwest along the coast from Cape Smythe an Eskimo last summer (1912) found a muskox skin and brought it to me for sale; it is in the Point Barrow collection which has just arrived at the Museum but has not yet been unpacked. Another Eskimo found a smaller piece of skin in another house which I believe to be of a muskox, though its badly decayed condition makes it difficult to say positively that it is not the skin of the barren-ground bear.

I have myself seen muskox skulls both in the delta of the Colville (imbedded in the earth) and on Herschel Island (on top of the ground).

Respectfully,

V. STEFÁNNSON

In this connection it may be recalled that Richardson in 1829[1] stated:

> From Indian information we learn that to the westward of the Rocky Mountains, which skirt the Mackenzie, there is an extensive tract of barren country, which is also inhabited by the muskox and reindeer.

But no muskoxen were found when this section of country was subsequently visited by white men. Muskox skulls, however, have been found upon the surface of the tundra inland from Point Barrow in a condition indicating a recent and not a Pleistocene origin. Thus Mr. John Murdock, of the International Polar Expedition to Point Barrow,[2] reported that just before leaving Point Barrow in 1884 a muskox skull was brought in by one of the trading parties which had been as far eastward as the Colville River, and he presumed that the skull had been brought from there, and adds:

> The natives knew the animal well, and called it by nearly the same name as the eastern Eskimos, but none had ever seen it alive. The skull obtained appeared very old and much weathered.

Some years later the McIlhenny Expedition to Point Barrow obtained "one weather-beaten [muskox] skull picked up on the tundra."[3]

[1] "Faun. Bor.-Amer.," I., p. 276.

[2] Rep., 1885, p. 98.

[3] Witmer Stone, *Proc. Acad. Nat. Sci. Phila.*, 1900, p. 35.

Mr. L. M. Turner, in referring to the muskox,[4] says:

> There is no positive evidence of the actual occurrence of this mammal within the region here included [the Yukon District and the Aleutian Islands]; but, as the northern Innuit and Indians are so well acquainted with it, there can be no doubt that it has but recently disappeared, if scattered individuals do not yet inhabit the region north of the Rumianzof Mountains near the Arctic coast.

In 1898, Mr. Frank Russell[5] made the following statement:

> The muskox was formerly common between the Mackenzie and Behring Straits, as evidenced by the remains which are scattered over the tundra. The oldest natives at Point Barrow say that their fathers killed muskox, which were then abundant.

Recently Dr. W. T. Hornaday has published[6] additional information furnished him by Mr. Charles D. Brower, who has lived at or near Point Barrow since 1884, much of which is in substance the same as that given above by Mr. Stefánsson. The latter, however, not only confirms the main details of Mr. Brower's account, but gives additional facts of considerable importance.

The information presented above, except that recently published by Dr. Hornaday, was gathered and published by me in 1901[7] apropos of the alleged then recent occurrence of muskoxen along the Arctic coast of Alaska east of Point Barrow, based on three fresh skins with their skulls shipped from Camden Bay to San Francisco and thence to New York, where, through the kindness of Mr. E. Bowsky, of New York City, I had opportunity to compare them with skins and skulls from the Barren Grounds east of the Mackenzie. A communication from Mr. A. J. Stone was published in the same connection to the effect that these muskox skins must have originally been obtained by whalers around the head of Franklin Bay or on Parry Peninsula

[4] "Contr. to Nat. Hist. Alaska," 1886, p. 203.

[5] "Expl. in the Far North," 1898, pp. 235, 236.

[6] *New York Zool. Soc. Bull.*, No. 45, May, 1911, pp. 754, 755.

[7] *Bull. Amer. Mus. Nat. Hist.*, XIV., 1901, pp. 81–83.

and by them taken to Camden Bay, as he had found no evidence of the recent existence of muskoxen in northeastern Alaska. This, however, does not in any way controvert the testimony afforded by skulls found on the surface of the tundra near the coast of this portion of Alaska, nor the facts now furnished by Mr. Stefánnson in confirmation of the previous evidence of the existence of living muskoxen there as recently as fifty to sixty years ago.

J. A. Allen

American Museum of Natural History

THE NATIONAL ACADEMY OF SCIENCES

At the New Haven meeting of the academy held in the new Sloane Physics Laboratory of Yale University, from November 12 to 14, the following papers were read:

Charles D. Walcott: "Cambrian Formations of Mount Robson District, British Columbia." Illustrated.

William M. Davis: "Physiographic Evidence in Favor of the Subsidence Theory of Coral Reefs."

William B. Scott: "Restorations of Tertiary Mammals."

Henry F. Osborn: "Geologic Correlation of Upper Paleolithic Faunas of Europe and America."

John M. Clarke: (1) "The Devonian Faunas of Western Argentina." (2) "Probable Devonian Glacial Boulder Beds in Argentina."

Charles Schuchert: "Climates of Geologic Time." Illustrated.

William M. Davis: "The Transcontinental Excursion of the American Geographical Society."

Arnold Hague: "Biographical Memoir of Samuel Franklin Emmons."

Jacques Loeb: "On the Fertilization of the Egg of Invertebrates with Blood."

Edwin G. Conklin: "Cell Division and Differentiation." Illustrated.

Charles B. Davenport: "Heredity of Skin Color in Negro-white Crosses."

Lafayette B. Mendel (introduced by Russell H. Chittenden): "Some Biochemical Features of Growth." Illustrated.

Thomas B. Osborne: "The Nutritive Value of the Proteins of Maize."

Ross G. Harrison (introduced by Russell H. Chittenden): "Experiments on Regeneration and Transplantation of Limbs in the Amphibia." Illustrated.

S. J. Meltzer: "Theory and Fact as Illustrated by an Instructive Experiment on the Splanchnic Nerve."

Franz Boas: "New Data on the Influence of Heredity and Environment upon the Bodily Form of Man."

Ernest W. Brown (introduced by Edward S. Dana): "The Problem of the Asteroids."

Robert W. Wood: (1) "Some Results obtained with the most Powerful Spectrograph in the World." Illustrated. (2) "On the Possibility of Photographing Molecules." (3) "On a New Method of Finding Regularities in Band Spectra."

Charles C. Adams (introduced by William H. Dall): "The Variations and Ecological Distribution of the Snails of the Genus *Io*."

SOCIETIES AND ACADEMIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Anthropological Society was held at 4:30 P.M., October 29, 1912, in Room 43 of the New Museum Building, the president, Mr. Stetson, in the chair.

Dr. I. M. Casanowicz read a very careful, thorough and interesting paper on the Mithra cult, explaining it as a religion of redemption, which was the most important competitor of Christianity during several centuries. He explained that it was Aryan in origin, antedating the separation of the Aryan people of India from the Iranians, that it was transferred westward by stages, accumulating elements in the Mesopotamian Valley and the Mediterranean Basin, but preserving an Iranian nucleus, that it entered Rome as the religion of the poor and lowly, but was taken up by society when found helpful to imperial policy and made its first convert of an emperor in Commodus. Mithra was essentially the god of light, hence of truth and benevolence; and from the antithesis of light and darkness grew the conception of his war against the powers of evil. Zoroaster built his system on this dualism and conflict, though relegating Mithra to a lower place. Later he came to be regarded as occupying a middle place (on earth) between the powers of Heaven and the evil powers of the underworld, serving also as a mediator between man and the unapproachable supreme deity. The cult of Mithra, he said, had influenced Christianity, especially in the conceptions of the powers of evil, the resurrection of the body, the efficacy of sacraments and the procedures of the church.

W. H. Babcock,
Secretary